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SURGICAL DIAGNOSIS

SURGICAL DIAGNOSIS

BY

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VOLUME II

INJURIES AND DISEASES OF THE ABDOMEN AND OF ITS CONTAINED VISCERA · THE RECTUM · INJURIES AND DISEASES OF THE KIDNEY, THE BLADDER, THE PROSTATE, THE URETHRA, PENIS, SEMINAL VESICLES, SCROTUM, TESTIS, AND SPERMATIC CORD

WITH THREE COLORED PLATES AND TWO HUNDRED AND FIFTY-THREE ILLUSTRATIONS IN TEXT

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SURGICAL DIAGNOSIS

VOLUME II

CHAPTER I

DISEASES OF THE ABDOMEN

DIAGNOSIS OF THE DISEASES OF THE ABDOMEN

Methods of Examination

Assuming that all possible information has been obtained relating to the previous history and present illness of the patient, the examination may be conducted on the following lines:

Inspection.—By viewing the abdomen from various directions and with the patient in various positions, much information may be obtained, sometimes of a very definite character, sometimes only suggestive, furnishing a hint as to the lines upon which the further examination should be conducted. The color and general appearance of the skin of the abdomen should be noted, and the presence of eruptions, scars, tumors, herniæ, sinuses, infiltrations. Lineæ albicantes (striæ) may be present, pink or raw-ham colored when recent, sometimes pigmented in brunettes. They indicate a previous distention of the belly, in women usually due to pregnancy; sometimes to obesity, ascites, a tumor, or other cause. Extreme degrees of distention from ascites or large tumors cause a peculiar smooth, glistening appearance of the skin, sometimes combined with edema, never present from mere obesity and usually associated with some cachexia. Emaciation of the face, thorax, and upper extremities may be present in such cases, and the legs may be swollen from edema. When the patient stands erect and is viewed from the front, we may see enlarged varicose subcutaneous veins radiating from the umbilicus (Caput Medusæ). They indicate interference with the portal circulation, as from cirrhosis of the liver and certain tumors of the liver (carcinoma). Large pelvic tumors which compress the iliac veins or the inferior vena cava, and extreme degrees of ascites, may produce visible enlargements of the epigastric veins, both inferior and superior, the blood finding its way into the internal mammary veins and veins of the diaphragm. An unusual dilatation of the veins of the spermatic cord, often greatly in excess in size and number of the veins found in varicocele, is strongly suggestive of a malignant tumor of the kidney, especially if it be upon the left side.

Herniæ, whether umbilical, ventral, inguinal, or femoral, are often visible by inspection in the erect posture. Diastasis of the recti muscles as the result of repeated pregnancies is readily visible; a large tumor, covered by little more than integument and containing intestine, etc., may project through the gap, and the edges of the recti are easily seen forming its boundaries. In these cases, and in large reducible umbilical herniæ with a dilated ring, palpation of the abdominal viscera may be extraordinarily easy. The thinned-out abdominal wall may be inverted into the belly by the examining hand and the viscera readily palpated. The size and shape of the abdomen are to be noted, whether normal, increased, or diminished in size, and, if increased, whether the enlargement is symmetrical or localized. Further, whether the abdomen bears a normal relative size to the thorax. Abdominal enlargement due to obesity is accompanied by a generalized thick panniculus adiposus over the thorax, buttocks, and extremities. Distention due to mere flatulence from intestinal fermentation, constipation, etc., is moderate in adults; in children it may be more marked, owing to the relatively greater size of the abdomen in infants. The appearance of the umbilicus should be noted. In ascites and tuberculous peritonitis the umbilicus protrudes; the same is true of the fluid accumulations in the belly accompanying malignant disease of the abdomen (cancerous peritonitis). Ascites from malignant disease is accompanied by emaciation, a cachectic appearance and a drawn, anxious facial expression; that from cirrhosis and malignant disease of the liver and biliary passages very often also by jaundice; that from cardiac and renal disease frequently by edema of the lower extremities. Ascites from tuberculous peritonitis may

Fig. 1.—Umbilical Hernia in a Man.
(New York Hospital, service of Dr. Frank Hartley.)

or may not be accompanied by anemic pallor. The pinched, anxious expression of malignant disease is usually wanting. Large uterine and ovarian tumors cause flattening of the umbilicus. In ascites the shape of the abdomen is that of a barrel when the patient stands erect. If the abdominal wall is at all lax and the patient lies upon his back, the front of the abdomen is flattened, the flanks bulge. In extreme degrees of ascites, owing to great intra-abdominal tension, such flattening may be wanting (see Fig. 3). A symmetrical, central, rounded tumor of considerable size, occupying the lower part of the abdomen of a woman, suggests pregnancy if she is young, a uterine fibroid if she is middle-aged or a negress. The surgeon will do well to remember that the two conditions may coexist. An ovarian cyst produces a rounded, prominent distention of the lower part of the belly projecting well to the front (see Fig. 4). If not very large, it is often most prominent to one side of the median line. Well-developed, diffuse, purulent, or fibrino-purulent peritonitis is attended by uniform abdominal distention; the presence of much air or gas in the peritoneal cavity by the same. The distention of intestinal obstruction is often localized at first. In the later stages general tympanites may entirely obscure the local signs, though not always. The local or general rigidity and want of mobility of the abdominal muscles during respiration accompanying peritoneal irritation from many causes, especially peritonitis, can often be recog-

Fig. 2. — Ascites from Malignant Disease of the Ovary. The patient was operated upon with no benefit. There were nodules of cancer scattered everywhere over the surface of the peritoneum. The exudate was bloody. (Author's collection.)

Fig. 3.—Ascites from Inoperable Cancer of the Uterus with Cancerous Peritonitis. (New York Hospital, service of Dr. F. W. Murray.)

nized by inspection as well as immobility of the costal border under like conditions.

Localized Swellings of the Abdomen.—Localized swellings of the abdomen occur from tumors of the abdominal wall and of the viscera, and may occupy any possible situation; further, from enlarged or distended organs and from localized exudates of any sort. Inspection of a localized swelling may, from its size, position, and shape, give a more or less accurate idea of its anatomical seat, and possibly of its character. It is important to note whether or not it moves with respiration. When comparing slight differences in the two sides of the belly, it is best to place the patient on his back on a firm, smooth, surface—a table, in fact—and to stand at some little distance, viewing the abdomen along the median line of the body. One may stand opposite the head or the feet, or each in turn. Tumors in the loin, whether of the kidney, the colon, or other, are best inspected by sitting the patient upright on a stool or laying him on his belly. Any bulging in the flank can thus most readily be detected by comparing the two sides. The *stomach*, when dilated, may form

Fig. 4.—Ovarian Cyst. (Kindness of Dr. C. L. Gibson.)

Fig. 5.—Uterine Fibromyoma. Note the rounded dome-shaped abdomen and the manner in which the abdominal wall falls away abruptly above the tumor. (New York Hospital, service of Dr. F. W. Murray.)

or may not be accompanied by anemic pallor. The pinched, anxious expression of malignant disease is usually wanting. Large uterine and ovarian tumors cause flattening of the umbilicus. In ascites the shape of the abdomen is that of a barrel when the patient stands erect. If the abdominal wall is at all lax and the patient lies upon his back, the front of the abdomen is flattened, the flanks bulge. In extreme degrees of ascites, owing to great intra-abdominal tension, such flattening may be wanting (see Fig. 3). A symmetrical, central, rounded tumor of considerable size, occupying the lower part of the abdomen of a woman, suggests pregnancy if she is young, a uterine fibroid if she is middle-aged or a negress. The surgeon will do well to remember that the two conditions may coexist. An ovarian cyst produces a rounded, prominent distention of the lower part of the belly projecting well to the front (see Fig. 4). If not very large, it is often most prominent to one side of the median line. Well-developed, diffuse, purulent, or fibrino-purulent peritonitis is attended by uniform abdominal distention; the presence of much air or gas in the peritoneal cavity by the same. The distention of intestinal obstruction is often localized at first. In the later stages general tympanites may entirely obscure the local signs, though not always. The local or general rigidity and want of mobility of the abdominal muscles during respiration accompanying peritoneal irritation from many causes, especially peritonitis, can often be recog-

FIG. 2. — ASCITES FROM MALIGNANT DISEASE OF THE OVARY. The patient was operated upon with no benefit. There were nodules of cancer scattered everywhere over the surface of the peritoneum. The exudate was bloody. (Author's collection.)

FIG. 3.—ASCITES FROM INOPERABLE CANCER OF THE UTERUS WITH CANCEROUS PERITONITIS. (New York Hospital, service of Dr. F. W. Murray.)

(See Diseases of the Stomach.) Inspection is very valuable in the diagnosis of dilated stomach. The shape of the tumor is so characteristic in many instances that its nature may be recognized at a glance.

The Intestine.—Peristaltic movements of the gut are often visible in cases of chronic obstruction from any cause, most often from organic stricture before the advent of total obstruction. In children and emaciated persons it is sometimes possible to observe peristaltic movements in lead and other colics, rarely as the result of mechanical, thermal, or electric stimulation of the skin of the abdomen in normal cases. When actual obstruction is present it is possible in thin adults and children to distinguish the separate distended coils of gut and to see peristaltic movements in them quite plainly. Extreme distention and paralysis of the gut obliterates these signs, notably in those cases where acute obstruction follows the chronic variety. For example, in a case of car-

FIG. 7.—DISTENDED GALL-BLADDER IN A CASE OF MALIGNANT DISEASE OF THE LIVER. The gall-bladder may be seen below the margin of the ribs and on a level with the umbilicus as a rounded projection. (New York Hospital collection.)

cinoma of the splenic flexure of the colon upon which I operated some time ago, the distended colon was nearly six inches in diameter and entirely filled the front of the abdomen; the appearance was simply that of general abdominal distention. I recall another case of volvulus of a very long sigmoid flexure in an old man. The partly strangulated sigmoid loop was fully two feet in length and of great size; its outlines were very plainly seen through the abdominal wall, although of course no peristaltic movements could be seen in this loop.

The Gall-bladder.—The distended gall-bladder may form a visible swelling a variable distance below the right costal border, in a line with the tip of the eighth or ninth ribs. It may be long and so low down as to reach below the umbilicus (see Fig. 7). It is only rarely that the merely distended gall-bladder is visible in this way. I recall but few cases, and these emaciated subjects. If not adherent, the tumor moves with the liver during respiration. Carcinoma of the gall-bladder may form a large, visible tumor.

The Liver.—Enlargements of the lower part of the right chest and upper right quadrant of the belly are often connected with the liver. Such may be

abscess, echinococcus, carcinoma, gumma, or other tumor. They will be seen, unless adherent, to take part in the respiratory movements of the liver. Carcinomatous nodules may be very evident below the costal border in front on

FIG. 8.—ECHINOCOCCUS CYST OF THE LIVER. (Kindness of Dr. Wm. A. Downes.)

account of accompanying emaciation. I saw a case showing gummatous nodules in the liver of a young man which was characteristic. There was no serious disturbance of nutrition and very little pain or local tenderness. The nodules were firm on palpation. They diminished in size rapidly under the use of iodid internally and mercurial inunctions. The syphilis was of the acquired

FIG. 9.—DR. CONNER'S CASE OF ACUTE DILATATION OF THE STOMACH FROM OBSTRUCTION OF THE DUODENUM. The patient had a diffuse tuberculosis of the liver and spleen. (New York Hospital collection.)

form. The projecting and elongated right lobe of the liver produced by tight lacing is occasionally visible as a slightly prominent tumor in poorly nourished young women. In cases of hepatoptosis, the right lobe of the liver may form

a visible tumor extending sometimes as low as the right iliac fossa. When the right lobe of the liver is greatly enlarged the deformity of the abdomen becomes general rather than local.

The Spleen.—Enlargements of the spleen seldom produce a distinctly localized swelling of the belly. As the spleen grows so large that it emerges from the left costal border, it conforms to the general shape of the abdomen, advances downward and to the right, and produces a general rather than a circumscribed abdominal distention. There are, however, exceptions to this rule. The right border of an enlarged spleen may be perfectly evident through a thinned abdominal wall. A large spleen moves but little or not at all during respiration.

Only very considerable enlargements of the *kidney* produce a visible swelling in front of one or other flank. A bulging of the lumbar region, seen from behind or from the side, is observable before the tumor projects to the front.

FIG. 10.—INFECTED HYDRONEPHROSIS OF A CONGENITAL MISPLACED KIDNEY. (Kindness of Dr. J. C. Ayer.)

A displaced and hydro- or pyonephrotic kidney may form a visible tumor in very unexpected situations. The case shown in Fig. 10 is of a man with a large, fluctuating, tense swelling in the right lower quadrant of the belly. The cystic tumor proved to be a hydronephrotic kidney. I recall another case, operated upon by Dr. Frank Hartley and later by Dr. Charles McBurney in the Roosevelt Hospital—a large cystic tumor presenting in the umbilical region of a boy of ten years; the cyst was the dilated ureter of a kidney lying horizontally across the brim of the pelvis.

The Urinary Bladder.—The urinary bladder when distended forms a centrally placed rounded eminence above the pubes. It may extend to the umbilicus. The introduction of a catheter, the escape of a large quantity of urine, and the disappearance of the tumor establishes its nature. I have known the bladder to be mistaken for a cystic tumor and incised.

A cyst of the *pancreas* presents as a rounded prominence or merely fullness in the upper part of the abdomen, usually in the middle line, occasionally to the left of the stomach below the costal border.

Fig. 11.—Greatly Enlarged Spleen (Banti's Disease). (New York Hospital, author's service.)

Localized exudates occasionally present as visible swellings, usually in the lower part of the belly, often in the right iliac fossa. Appendicitis, psoas abscess, etc., sometimes in the lumbar region at the outer border of the quadratus lumborum. Tuberculous abscess connected with the spine, perinephritis. A tumor which overlies the abdominal aorta may receive a visible transmitted pulsation. An aneurism in the abdomen may sometimes be seen to pulsate.

Diminution in the Size of the Abdomen.—The concave or scaphoid abdomen is observed as the result of intense peritoneal irritation. In peritoneal sepsis, intraperitoneal hemorrhage, or in any case where irritating material in quantity is suddenly poured into the peritoneal cavity. I noted it a few days since in a case of hemorrhagic pancreatitis. It is also seen in chil-

Fig. 12.—Distended Urinary Bladder Containing Eighty-eight Ounces of Urine. Patient was an old man with prostatic obstruction. (New York Hospital.)

dren with tuberculous meningitis and as a chronic condition in many forms of inanition, notably in starvation from esophageal stricture, benign and malignant, in cardiospasm, and as a part of general emaciation from constitutional causes. In times of famine, when the little food taken is of improper

FIG. 13.—SARCOMA OF THE PELVIS FORMING A LARGE ABDOMINAL TUMOR IN A CHILD; INOPERABLE. (New York Hospital collection.)

quality and intestinal fermentation exists, the bellies of starving wretches are commonly distended with gas. The abdomen looks very large in comparison with the emaciated limbs.

Palpation.—Of all the methods of examining the belly, palpation is the most valuable. To do it really well, so that the greatest possible amount of information is obtained, is not easy. The art may be acquired by practice and

FIG. 14.—FIBROMYOMA OF THE UTERUS. Mucous degeneration of the tumor with the production of a large hernia consisting of tumor tissues chiefly. The surface of the tumor at the time the photograph was taken had become gangrenous over its lower half. Note the dilated subcutaneous veins in the lumbar region produced by pressure upon the venous trunk of the abdomen. (New York Hospital, service of Dr. F. W. Murray.)

attention to details, and he who wishes to be a skillful diagnostician of abdominal diseases should seek every opportunity to perfect himself in abdominal palpation. A thorough familiarity with the topographical anatomy of the abdo-

men is necessary for an intelligent judgment of diseased conditions. Special methods of examination, some of them about to be described, have their value, and are sometimes very useful aids, but in most cases the results of abdominal palpation determine the diagnosis and the question of operability. By palpation we discover tenderness, rigidity, a sense of resistance, the presence of a tumor, together with its physical characters, hardness, softness, fluctuation, the presence of pulsation, of "hydatid fremitus," further, mobility; changes in the size and form of organs, etc. In order properly to examine the abdomen, the patient should lie upon his back and upon a level firm surface, with a small pillow under his head. The room should be warm. The entire abdomen should be exposed, including the lower part of the thorax. In order to relax as far as may be the abdominal muscles, the patient lies with the thighs and knees flexed. Under special conditions other positions may be assumed. He may sit, or stand, or lie upon his side. The genupectoral position is sometimes useful and the dorsal position with elevation of the pelvis. During the examination the patient may be directed to breathe quietly and deeply and to open his mouth. It is important that the patient should neither be frightened nor hysterical, else a satisfactory examination may be difficult or impossible. It is sometimes well to divert the patient's attention by conversation. It goes without saying, that the thinner and more lax the abdominal wall, the easier the examination will be. The surgeon's hands should be warm, and the manipulations should be made as gently as possible to avoid muscular spasm. If, as is sometimes the case, the patient is unable to relax his belly wall, no satisfactory examination is possible. In these cases a general anesthetic may be necessary. The complete muscular relaxation of anesthesia enables one to make a thorough examination with comparative ease. *Every abdominal examination should include vaginal or rectal palpation in the female and a rectal examination in the male. By making this an invariable rule, the surgeon will save himself many embarrassing errors in diagnosis.* Whenever possible, it is desirable that the large intestine should be emptied by an enema to get rid of scybalous masses and of gas. The hands are used to palpate the abdomen in several ways. For general purposes both hands are placed side by side, palms downward, upon the surface of the belly with the fingers a little flexed. By depressing the belly wall gently the tension of the abdominal muscles is appreciated as well as the presence of tenderness felt by the patient. The hands are caused to travel slowly over the entire abdomen without lifting them, since this maneuver is less likely to cause muscular contractions than though the hands were lifted and reapplied. In case the history or subjective sensations of pain, etc., render it probable that some particular region is the seat of trouble, it is well in order to gain the patient's confidence, quiet his fears, and avoid the occurrence of muscular spasm, to begin the examination in a region believed to be normal, and gradually to approach the probable seat of the lesion. Localized muscular rigidity and localized tenderness are thus readily discovered. In order to locate accurately the point of greatest tenderness, point

pressure with the tip of the index finger is very valuable. Having found an area of tenderness, the finger is used like a pointer to depress successively different portions of the abdominal wall. (See Peritonitis and Appendicitis.) Localized rigidity and tenderness may be due to lesions of the abdominal wall, to irritations and inflammations of the peritoneum, or to a lesion of an underlying viscus, or to a tumor, or an inflammatory exudate. When the lesion is deeply placed in the abdomen, firm, deep pressure may be necessary to elicit tenderness or to feel a tumor or sense of resistance, as the case may be. Deep pressure may be made by placing one hand over the other; the upper hand makes pressure while the fingers of the lower hand are used to appreciate the resistance, the tumor, the limits of an organ, etc. When palpating the shape, size, limits, and consistence of a tumor the fingers are flexed, and their tips alone are used in the operation. (See Diagnosis of Tumors of the Abdomen in the following pages.) In palpating the loin, as in examining the kidney, a tumor of the colon, etc., one hand is placed upon the abdomen in front, while the other is used to make counter pressure behind between the ribs and the crest of the ilium. In making this examination it is sometimes desirable to turn the patient on the sound side with his knees and thighs flexed, and to place an air cushion beneath the sound loin, and thus increase the space between the ribs and the pelvis on the side to be palpated. In palpating the belly, it is important to bear in mind the distinction between a sense of resistance and the actual presence of a palpable tumor. The former may be due to a variety of conditions in the abdominal wall or in the abdominal cavity, and is of no very definite diagnostic value without the presence of other associated signs and symptoms; the latter, on the other hand, constitutes a definite diagnostic entity. Inexperienced diagnosticians are very apt to assume the presence of a tumor when a sense of resistance merely is present. The outer border of the rectus muscle, especially in the upper part of the belly, may readily be mistaken for an enlarged gall-bladder, a tumor of the pylorus, etc. In the right iliac region the edge of the rectus is very commonly mistaken for the vermiform appendix. The contents of the large intestine may readily be mistaken for a tumor. In making deep abdominal palpation the patient is directed to breathe through his mouth; if this does not permit sufficient depression of the abdominal wall, he is told to take a very deep breath, and then to let it out fully. At the beginning of expiration deep pressure is made, and the depression of the abdominal wall thus gained is held. Another deep inspiration and full expiration is followed by a further effort on the part of the surgeon to depress the belly wall; this maneuver is often successful. It is especially useful in trying to palpate the lower border of the liver, the fingers being crowded up beneath the ribs. Some surgeons prefer to utilize the relaxation of the abdominal wall during inspiration for making pressure. Children may be made to cry during the examination, and the moment of greatest relaxation of the abdomen is then utilized for palpation. The presence of free fluid in the abdomen is detected partly by palpation, partly by percussion. In cases of ascites

accompanied by enlargement of the liver, the presence of fluid can sometimes be appreciated by placing the fingers over the right or left lobe of the liver and making quick flexion of the finger-tips. A sense of elastic tension, which is overcome by the fingers and the firm resistance encountered by the fingers as the abdominal wall comes into contact with the liver surface, is much easier to appreciate than to describe. The sense of a layer of fluid forced aside is unmistakable. Free fluid is also detected by sharply tapping or flipping one side of the abdomen with a finger while the other hand is placed upon the opposite flank. A distinct fluid wave transmitted across the belly is felt. Percussion in these cases gives dullness or flatness in the flanks up to a certain level and tympanitic resonance of the highest part of the abdomen in front. As stated elsewhere, flatness will exist in front also when the amount of fluid is great or when the intestines are held down by a shortened mesentery, whether natural or contracted by inflammatory or malignant infiltration. In cases of echinococcus cyst of the abdomen a characteristic sign is a peculiar tremulous motion of the abdominal wall seen and felt when the cyst is smartly agitated or tapped with the fingers. In cases of ascites from any cause the patient may be turned upon his side. Percussion will then give tympanitic resonance in the upper flank where flatness existed before. In cases of intra-abdominal hemorrhage the following sign is said to be of diagnostic value in some cases: Flatness in the flanks having been determined, the patient is turned upon his side. Flatness gives place to tympanitic resonance in the upper flank, not immediately, but after several minutes, since the partly coagulated blood moves but slowly to the dependent portions of the belly (Mayo Robson). In thin persons with relaxed abdominal walls the cecum and the beginning of ascending colon can often be palpated even when empty, and the same is true of the descending colon as it passes over the brim of the pelvis. When distended by feces the ascending, transverse, and descending colon can all be felt. When inflated with gas, naturally or artificially, the colon can be mapped out by percussion, sometimes by palpation. Since percussion and palpation are commonly used successively, we shall consider them together in speaking of the examination of the different organs.

Percussion.—Abdominal percussion may be made with the fingers alone, or with the aid of a little ivory or hard-rubber plate (plexímeter), and a small hammer, the striking surface of which is armed with soft rubber. The former method is more generally useful. As in percussion of the thorax, the palmar surface of the left middle or index fingers is laid flat upon the area to be percussed, and held firmly against the surface. The middle phalanx of this finger is then struck a series of quick, sharp blows with the flexed index or middle finger of the other hand. The vigor of these blows is regulated by the thickness of the abdominal wall, and by the depth and character of the underlying structures whose resonant qualities we desire to ascertain. The sound produced varies in duration, pitch, and other qualities; as, for example, over solid organs, tumors, thick layers of fluid, no resonant tone is produced (flat-

ness); over air-containing organs, cavities, or tumors, a high-pitched tympanitic note; over greatly distended stomach or intestine, sometimes resonance of a metallic character; over certain organs and regions, a modified tympanitic resonance, dullness, etc. To correctly interpret the value of these various sounds requires long practice and careful observation. Percussion is used to map out the boundaries of organs and large tumors, to determine the presence of free fluid or of encapsulated exudates. It is important to bear in mind that if a layer of fluid is thin and overlies intestine, or if a tumor or organ, whether solid or filled with fluid, is small and thin, and lies superficial to the gut, very light percussion only will elicit dullness. If, on the other hand, a tumor, an organ, or exudate is deeply placed, the abdominal wall must be depressed, and firm, deep percussion used to elicit dullness. Light percussion will give the tympanitic resonance of the overlying gut. Deep percussion must also be used in the loins and in any case where the abdominal wall is thick from a deposit of fat. (The value and use of percussion will be discussed under Diseases of Special Organs; a few important details only will be mentioned here.) Retroperitoneal tumors and organs when enlarged push the intestine away in front of them; thus the presence of a hollow organ (colon, stomach) in front of a tumor, as determined by percussion, may be of diagnostic significance. Tumors of the kidney push the colon in front of them and toward the median line. Thus a tumor in the flank, giving flatness on percussion in the axillary line, but crossed by a band of tympanitic resonance in front or toward its inner side if the tumor be very large, is characteristic of a tumor of the kidney. Changes in the percussion note over tumors after inflation of the stomach or colon are often of diagnostic value. Absence of liver dullness after an injury of the abdomen is suggestive of rupture of the intestinal tract and an accumulation of gas between the liver and the abdominal wall. In the presence of marked tympanites it may be due to upward displacement of the liver by distended intestine, as observed in some cases of peritonitis. (For further details, see Diagnosis of Abdominal Tumors and Disease of Special Organs.)

Auscultation.—Auscultation of the abdomen furnishes valuable information in a few conditions; in others, none at all; in still others, information of a suggestive but not positive character. The ear may be laid directly upon the abdominal wall, or a binaural stethoscope may be used; at times auscultation may be combined with percussion—auscultatory percussion. For this purpose the instrument known as the phonendoscope may be used, and is said to give accurate information. It is not generally employed by surgeons. Certain sounds heard in the abdomen are of positive significance. The fetal heart sounds, for example, are proof positive of pregnancy, and may exercise an important bearing upon the treatment of abdominal tumors, notably uterine myomata and ovarian tumors. The bruit of abdominal aneurism may in the presence of expansile pulsation and other signs render a diagnosis positive. In other instances the information may be suggestive merely, as in the case of pulsating sarcomata or of tumors pressing upon the aorta which receive a

transmitted pulsation, and may be accompanied by a murmur. Certain sounds may be heard in the vicinity of a partly obstructed portion of gut. In the large intestine chronic obstruction may cause gurgling sounds heard always over the same area, and so of diagnostic significance. Succussion (splashing sounds) can often be elicited in the large intestine when it contains a mixture of gas and fluid. This is especially noticeable when the intestine is distended above an obstruction. Similar sounds can often be elicited by palpation of the full stomach in health. They are marked when the stomach is dilated. The outlines of the normal stomach can scarcely be made out definitely by ordinary palpation and percussion. When the stomach is empty, its greater curvature can sometimes be mapped out in the following manner: The patient stands erect; an area of relative dullness in the epigastrium having been discovered, the patient is caused to drink several glasses of water. Percussion may then show a definite area of dullness corresponding to the greater curvature of the stomach (von Mikulicz). When the patient lies on his back the dullness disappears. The stomach may be inflated for diagnostic purposes to determine its size, shape, position, etc., either with carbonic-acid gas or with air. This method of examination should not be used after injuries of the abdomen, after hematemesis, or in any case where the presence of an ulcer of the stomach or a weakened stomach wall is suspected. The simplest method of inflating the stomach is to administer by the mouth, successively, a solution of sodium bicarbonate: Sodii bicarb. (1 drachm); water (3 ounces); followed by tartaric acid, 30 to 40 grains; water (3 ounces). A stomach-tube should always be at hand to relieve the patient in case the distention of the stomach is excessive. A safer and more reliable method, although disagreeable, is to pass a stomach-tube and inflate the stomach to the desired extent, with a suitable attachment of rubber hand bulbs, such as are used with the Paquelin cautery. The stomach can then be mapped out by percussion quite accurately, and unless the abdominal wall is thick, the general outline of the greater curvature can be seen as a visible swelling. The injection of air or water into the large intestine is used for diagnostic and therapeutic purposes. The injection of air may be used in the diagnosis of certain tumors of the abdomen, and occasionally may be of aid in determining the seat of obstruction in the large gut. The inflation of the bowel with hydrogen gas was proposed and used by Senn for the detection of perforating wounds of the intestine. It is, I believe, no longer advocated for this purpose. In diagnosis of tumors the injection of air may serve to displace a tumor in a definite direction, and thus identify its anatomical seat (see Diagnosis of Abdominal Tumors), or by changes in the percussion note to determine its relation to the colon. Thus, in tumors of the kidney the colon lies in front, and, when inflated, produces an area of tympanitic resonance over the growth where dullness may have existed before, or displaces the growth upward behind the liver, thus differentiating it upon the right side from an enlarged gall-bladder. In cases of obstruction of the large gut, inflation may serve to indicate the limit of the distensible intestine, and so the seat

of the obstruction. The advantages of air over water are: It is more easily and quickly introduced. It gives a sharp differentiation between flatness and tympanitic resonance. Its disadvantages are: The amount of air injected cannot be accurately gauged, nor the degree of pressure exerted on the wall of intestine. The surgeon must be guided by the subjective sensations of the patient and the visible degree of distention. The method is, therefore, not devoid of the danger of rupture of the gut. The bowel may be injected with air through any suitable soft instrument, a stomach-tube or rubber catheter introduced into the anus and connected with suitable air hand bulbs. As stated, the amount of air injected cannot be accurately gauged, and the surgeon must be guided by the sensations of the patient and the apparent degree of distention of the bowel. The method should be used only with the greatest caution. The injection of water into the bowel has the advantages that the amount injected is accurately known; that the pressure can be exactly controlled from moment to moment; that the procedure is sometimes a very valuable one in cases of obstruction of the lower bowel from twists and kinks; impaction of feces and other conditions from a diagnostic, occasionally from a therapeutic point of view. With patience water can be injected as far as the ileo-cecal valve or even beyond, assuming that no obstruction exists below. The apparatus used are a funnel and a soft-rubber stomach-tube or other soft instrument, properly lubricated, and inserted a few inches inside the anus. *There is no advantage gained by trying to insert the tube far up the bowel;* if soft, it will probably catch in a fold of mucous membrane and turn upon itself. If hard, the bowel may be perforated. Normal salt solution is less irritating than plain water, and to be preferred. A drachm of salt to a pint of water answers well. The patient should lie on his back with knees drawn up. If the injection is to be large, there is a decided advantage in elevating the hips even to an angle of thirty degrees, thus favoring the entrance of water into the sigmoid flexure and above by gravity, and avoiding much of the annoying rectal tenesmus from distention of the ampulla of the rectum. In adults it is safe to use three liters or even more of water. The utmost patience should be used in filling the bowel. A height of water in the funnel above the anus, just sufficient to make it flow, is the safest guide to the proper pressure. This will amount to about eighteen inches. A height greater than a yard should not be exceeded, nor should the funnel be maintained at this height continuously. When the rectum is distended, the patient may have an almost uncontrollable desire to expel its contents. If the flow of water be stopped for a moment, the liquid will find its way up the bowel, the spasm will cease, and the water may be permitted to flow again. When the bowel is fully distended, the escape of the water may be facilitated by the introduction of two well-greased fingers into the anus. The fingers being separated a little, the water escapes rapidly between them. In infants distention of the bowel with water is sometimes practiced as a therapeutic measure during the early hours of intussusception. The patient may be inverted during the performance; the greatest care should be used not to exceed

a very moderate pressure; a quart of water may be introduced. In adults when fecal impaction is present or suspected, if water does not serve to stimulate the atonic intestine, the performance may be repeated, using half a pint of olive oil containing a little turpentine, or an ounce or two of castor oil at first, followed by water; in this manner the oil may be carried far up the intestine, and act more efficiently to break up scybalous masses and stimulate peristalsis. The diagnostic value of large enemata of water will be mentioned under Tumors of the Abdomen.

The X-rays.—The X-rays are a useful aid in the diagnosis of certain abdominal conditions. Notably in the detection of calculi in kidney, ureter, and bladder, and of metallic foreign bodies in the alimentary canal. Gall-stones in the gall-bladder have been shown in skiagraphs in a few instances. As a means of diagnosis in gall-stone disease the method will probably never be of much value. (See X-rays.) A dilated stomach can be demonstrated by causing the patient to swallow a stomach-tube or hollow bougie loaded with fine bird shot, and taking a skiagraph while the instrument is in the stomach. The skeleton of an abdominal fetus or lithopedion might well appear on a good X-ray negative. Large solid or cystic tumors of the belly usually cast a visible shadow. Displacement of the diaphragm upward by tumors or exudates can readily be demonstrated even with the fluoroscope. Bony tumors connected with the pelvic or other bones can readily be demonstrated by an X-ray picture. Destructive osteosarcomata of the spine or pelvic bones often give a very characteristic picture. Loss of the normal outline of the bones, loss of substance, the production of thin, branching, bony lamellæ in the substance of the tumor, of irregular cavities in the bone, etc., may all be seen.

DIAGNOSIS OF TUMORS OF THE ABDOMEN

The local conditions render the diagnosis of abdominal tumors a very different and, in general, a much more difficult problem than is the case with tumors upon or near the surface of the body. The former lie hidden usually from sight, and not infrequently from touch. Under the most favorable conditions only a part of an abdominal tumor is accessible to palpation, and it is well to bear in mind that *we are almost certain to underestimate the size of the abdominal growth.* The part we feel is, indeed, often but an outlying portion of a much larger mass inaccessible to our fingers. In the case of tumors not to be felt at all we must make our diagnosis by inference from other local and general signs and symptoms, if, indeed, we are able to make any definite diagnosis before opening the belly. Even after the abdomen is opened careful search and inspection may be necessary for a diagnosis. The difficulties may be greatly increased by adhesions, by a large fat abdomen, and other local conditions. The surgeon who makes the most careful preliminary study of his cases will, in general, be in a better position to find and interpret the lesion at once. In certain cases, though the lesion is readily found, we may still be

in doubt as to its nature. A few months ago I opened the abdomen of a woman with a large tumor of the cecum. The appearances were those of carcinoma of the gut, with secondary carcinomatous nodules scattered over the neighboring peritoneum. The pathological diagnosis was tuberculosis. This error has been made many times by others. The gross characters of the two conditions may be identical. In order to overcome the difficulties of the situation we call to our aid a number of diagnostic devices, some of them of great assistance: the cystoscope, the ureteral catheter, the proctoscope, the X-rays, the analysis and pathological examination of the urine, the gastric contents, occasionally the feces, the blood. We study the effect of gastric and intestinal inflation upon the position and relations of palpable tumors. We must also take into account the evidences furnished by the general condition of the individual and the signs and symptoms of interference with the function of special organs. Among the general disturbances which may be suggestive are jaundice, pointing probably to disease of the liver or biliary passages; rapid emaciation, pointing to malignant disease or to obstruction of the cardiac end of the stomach or esophagus, sometimes to stricture of the pylorus or duodenum; the presence of fever, suggesting an inflammatory process, though fever is usually present when a tumor is undergoing rapid degenerative changes or has become necrotic, as sometimes happens to fibromata of the uterus; an ovarian cyst with twisted pedicle, etc. Further, malignant tumors are frequently accompanied by fever even when not undergoing ulceration or other degenerative change, sarcoma and Hodgkin's disease, for example. In chronic inflammatory processes, actinomycosis, tuberculosis, etc., fever may be absent. Profound anemia from advanced malignant disease, or from the atypical hemorrhages accompanying uterine fibroids, is common and is often of prognostic as well as diagnostic value. The acute intense anemia of ruptured ectopic pregnancy is easily recognized, and with a characteristic history goes far to render a diagnosis plain. The *urine* may furnish valuable information not only in lesions of the kidney itself, but also of other organs. Pyuria, hematuria, fragments of calculi, tumor cells in the urine—are all suggestive. Thus I was able to make the diagnosis of a degenerating sarcoma of the kidney by the presence of a vast number of sarcoma cells in the urine, together with much fat. The gross appearance of the urine was that of marked pyuria. The patient, a man, was intensely septic, had a temperature of 105° F., and a rapid pulse. The large tumor in the loin was elastic and fluctuating, suggesting pyonephrosis. *Bile* may be detected in the urine when jaundice is not evident on inspection. A large excess of indican in the urine suggests fecal impaction or obstruction in the colon or ileum. Free fat in the stools, together with glycosuria, suggests disease of the pancreas. The blood of leukemia explains a tumor of the spleen. The disturbance of function of special organs is often suggestive. Some of these have been noted above. Other examples are: Pain in the bladder; disturbances of urination; pain in the urethra and glans penis point to disease of the kidney quite as directly as to lesions of the lower genito-urinary tract, and it is remark-

able how many surgical lesions of the kidney are treated for cystitis, etc., for long periods. Atypical hemorrhages from the uterus point to uterine myomata, sometimes to ectopic gestation; a bloody discharge with a foul odor to cancer; tapelike stools to obstruction of the *rectum* in certain cases; often absent in cancer. Chronic obstruction of the gut higher up may be attended by constipation or diarrhea. Visible and palpable peristaltic movements and intermittent rigidity of the stomach and bowel point to obstructive tumors of the alimentary canal or to stricture. Tumors of the stomach are usually attended by gastric dyspepsia, often by vomiting. If they obstruct the pylorus, by a dilated stomach, by changes in the gastric juice, by abnormal fermentation of the stomach contents, and the accumulation of large quantities of food in the dilated organ. (Further details will be found under Tumors and Diseases of Organs.) It cannot be impressed too strongly upon him who seeks to correctly diagnosticate the surgical diseases of the abdomen, that he must not be satisfied with a diagnosis based upon the examination of one organ or set of organs. He should study not only the local lesion, but the general condition of his patient and the functional activity of all his viscera. Only in this way can the surgeon avoid distressing and humiliating errors of diagnosis. Errors will, of course, be made, but if due care has been exercised they will in no sense be blameworthy. The importance of trying to distinguish between a mere sense of resistance in palpating the belly and a definite intra-abdominal mass or tumor has already been noted. In the following pages the word tumor, as applied to intra-abdominal conditions, is to be understood to mean the presence in the belly as discovered by touch of a mass of more or less definite size, shape, and consistence where no such body normally exists. Such a mass may be an acute or chronic inflammatory exudate, an enlarged, distended, or displaced organ, or a true neoplasm.

Local Signs and Symptoms of Abdominal Tumors

In palpating abdominal tumors we are, as stated, handicapped by the fact that much of the surface of the tumor is inaccessible to touch, and that the abdominal wall of varying thickness and tension is always interposed between the examining hand and the tumor. Only in very thin and flabby bellies, such as are found in some women who have borne many children, or who have a greatly enlarged umbilical ring, diastasis of the recti, or a large ventral hernia, are we able to palpate an abdominal growth with the precision possible in superficial tumors. In distinctly pelvic affections in the female, bimanual palpation furnishes a partial exception to this statement, as already described. As a consequence many of the physical qualities of a tumor may remain unknown, and it is only too easy to draw wrong conclusions from those more or less indefinitely felt. The qualities we try to recognize are: (1) Size. (2) Surface. (3) Form. (4) Consistence. (5) Mobility. (*a*) Respiratory mobility; (*b*) Passive mobility. (6) Changes in position caused by inflation of the stomach and intestine.

Size.—As stated, the size of an intra-abdominal tumor is apt to be underestimated, a part only is accessible to touch, and in the case of tumors lying deep in the abdomen or beneath the ribs the main part of the mass is often beyond our reach.

Surface.—It is often difficult to judge correctly the character of the surface of an abdominal growth. The abdominal wall causes inequalities in the surface of the tumor to be inappreciable, unless the tumor is of considerable size and the inequalities marked. Many tumors which feel quite smooth are found in operation to be knobby and uneven. Thus, in trying to distinguish between a benign and malignant growth by this means we are often deceived. It is further to be remembered that many malignant abdominal tumors long conform to the shape of their containing organ or long remain covered by an investing capsule of connective tissue and peritoneum. Tumors of the stomach, the liver, the gall-bladder, the kidney, and carcinoma of the body of the uterus belong in this category, as well as many retroperitoneal growths.

Shape.—Tumors of certain organs often have a characteristic shape, and when such can be recognized, the information may be valuable. An enlarged gall-bladder is pear-shaped or cylindrical. Tumors of the kidney very commonly preserve the form of this organ, even when of large size. A sharp transverse lower border indicates liver. A notched border directed downward and to the right projecting from beneath the left costal arch is characteristic of spleen. Tumors of the intestine and of the lesser curvature of the stomach are sometimes cylindrical; the same is true of the intestinal tumor found in intussusception. Fibroid tumors of the uterus are often dome-shaped, and the abdominal wall falls away abruptly above them; often they are knobby, and movable outlying tumor masses are frequently present. Ovarian cysts are rounded and smooth. If large, they are symmetrically placed, and may occupy the greater part of the abdomen.

Consistence.—It is exceedingly difficult to correctly estimate the consistence of an intra-abdominal growth unless it be of very considerable size or can be firmly palpated between both hands, or is fixed. Small movable tumors usually feel much harder than they really are, and large tumors frequently give a sense of elastic fluctuation when they are really solid. Soft sarcomata and lipomata, whether of the kidney or other retroperitoneal structure, often transmit a sense of fluctuation to the hand. It will often be difficult, for example, to distinguish by palpation between a pancreatic cyst and a retroperitoneal sarcoma (von Mikulicz). If fluctuation is certainly present we naturally think of a tumor of an organ where cystic dilatations are prone to occur—pancreas, kidney, gall-bladder, liver (echinococcus), ovary—and not of the stomach or intestine (von Mikulicz). A mass of boardlike hardness suggests infiltration of the abdominal wall itself (actinomycosis, tuberculosis) (von Mikulicz). Large fecal accumulations in the colon have the distinguishing character on palpation that they can be indented with the fingers, and that the indentation remains. A further sign was described by Gersuny—namely, that

the wall of the bowel remains stuck for a time to the depression created by the fingers in the fecal mass, and can, after a time in certain cases, be felt to liberate itself. Some dermoid cysts can also be indented with the fingers and more or less molded on account of the puttylike character of their contents. The sign is less distinct and less often present than is the case with fecal masses.

Percussion.—The information obtained by percussion over abdominal tumors is, in general, less reliable than that obtained by palpation. Large solid or fluid tumors in contact with the abdominal wall give flatness on percussion, shading off into modified tympany and tympanitic resonance. In trying to define the limits of a large tumor of the abdomen by percussion, if we find that upon one side the dullness or flatness passes into tympanitic resonance while upon the other no limit can be discovered for flatness or dullness, as the case may be, it indicates that the origin of the tumor will be found upon this latter side. This may serve to identify the organ from which the tumor grew. In many tumors, notably of the stomach and intestine, dullness, if present over the tumor at all, will only be relative, usually a modified tympany. It is also to be borne in mind that a tumor may contain the gas of decomposition (infected ovarian cyst), and thus give tympanitic resonance. The importance of tympany over a tumor of the kidney has already been noted as establishing its relation to the colon. In cases of obstruction or dilatation of the stomach and intestine we may by percussion map out the boundaries of the distention, as noted under methods of examination.

From the results of palpation and percussion, in conjunction with the anatomical site of a tumor and the general and local disturbances accompanying its presence, we may, in certain instances, draw correct conclusions as to its nature, and, what is very important for the surgeon, as to its origin. For the determination of this latter question, and of the question of operability, the mobility of a tumor is very important.

Mobility.—It is to be borne in mind that *the formation of adhesions between the tumor and other organs, or the abdominal wall, only too often obscures the data to be derived from mobility.* The mobility of a tumor may depend upon the mobility, as a whole, of the organ in which it is growing, and such mobility may either be increased or diminished by the presence of the tumor. Thus, central or sessile tumors of the liver or tumors of the kidney partake only of the movements of these organs as a whole; or, on the other hand, the mobility of a tumor may depend upon the relative mobility of different portions of the same organ—i. e., among stomach tumors, those of the pylorus may move very freely; those of the greater curvature, scarcely less so; those of the lesser curvature are much less freely movable. Tumors of the cardia are rarely palpable; if large enough to be felt, their mobility is relatively slight. In the case of hollow organs—stomach and intestine—mobility may depend upon motion in the wall of the organ and its degree of distention. In the case of pedunculated growths the tumor has a degree of mobility quite independent of the organ from which it springs.

The mobility of a tumor may be of three kinds: (*a*) Movements accompanying respiration; (*b*) changes in the position of the tumor caused by artificial distention of the stomach and colon; (*c*) passive mobility.

(*a*) Movements Accompanying Respiration.—*Respiratory Mobility.*—The elevation of the costal border during inspiration drags the abdominal wall *upward*, a corresponding movement downward occurs during expiration. The upper portion of the abdominal wall takes a more active part in these movements than the lower; and the movements are more marked in women than in men. The *downward* movement of the diaphragm during inspiration forces the abdominal contents downward, a corresponding movement upward occurs during expiration. These latter movements are more marked in men than in women. These costal and diaphragmatic movements take place in opposite directions. Tumors in or adherent to the abdominal wall take part in the respiratory movements of the costal type—i. e., they move with the abdominal wall.

A sign already mentioned under Tumors of the Abdominal Wall is useful to distinguish tumors attached to the skin, subcutaneous tissues, or, in fact, to any of the layers of the abdominal wall in front of the transversalis fascia, from those attached to this latter layer. If the patient is placed in a sitting posture, and is caused to contract his abdominal muscles, tumors of the first class will become more prominent. If attached to the muscular layers they will become fixed. Tumors attached to transversalis fascia will become less prominent; they will also become immovable.

The diaphragmatic respiratory movements affect to a perceptible degree the liver and gall-bladder, also tumors in contact with or firmly adherent to the under surface of the liver, notably tumors of the pylorus. The liver and such tumors of the pylorus descend during inspiration and rise during expiration. The question of the operability of a pyloric tumor often depends upon whether it has secondarily invaded the gall-bladder and liver or not. The question may sometimes be answered in the following way (Minkowski): If not adherent to the liver, but merely in contact with it, the tumor will descend during inspiration and rise passively during expiration. If, however, the pyloric tumor can be grasped by the fingers, or if the fingers can be sunk between the lower border of the liver and the tumor, and if then the tumor is still dragged upward by the liver during expiration, it is firmly adherent to this organ or to the gall-bladder; and, if malignant, will probably be found inoperable. The organs below the stomach are but little affected by the movements of the diaphragm. The *pancreas* not at all.

The *spleen* and *cardiac* end of the *stomach* move less than the liver, and when normal, of course, cannot be palpated. A greatly enlarged *spleen* is moved but slightly, if at all, during respiration. The *normal kidney* moves up and down, and its movements vary in extent, according to the depth of respiration. These movements can sometimes be observed during abdominal operations. A *movable kidney* moves still more, and can be seen to make wide excursions up

and down when exposed in a wound. Incidentally, I have often demonstrated the respiratory mobility of the kidney when taking X-ray pictures of kidney stones. The vertical diameter of the stone, as shown on the plate, is often notably greater than its real diameter as seen at the time of its operative removal; the horizontal diameter is relatively less increased.

It is very difficult to palpate the normal kidney, and thus detect its respiratory mobility, except in very thin subjects. The fact that it can be readily felt always arouses a suspicion that the kidney is enlarged or is displaced or unduly movable. Still, it is sometimes possible to feel the kidney in emaciated subjects quite clearly. I recall the case of an old gentleman who was very thin and somewhat out of health; his right kidney was quite easily palpable; on this basis he had been told that a tumor of the kidney existed requiring operation. He sought other advice, refused operation, and continued to live without evidence of kidney trouble for many years.

(*b*) Mobility Caused by Distention of the Stomach and Colon with Air.—The injection of air into the stomach or the colon causes changes in position, not only of the distended viscera themselves and of tumors which they may contain, but of neighboring viscera, and of tumors in the vicinity of the distended organs. An important general rule to be borne in mind is that abnormally movable organs (kidney) and tumors, other than those of the distended viscera, tend to be displaced in the direction whence they came—i. e., a movable kidney tends to resume its normal position, etc. The following displacements as the result of inflation of the stomach and bowel have been demonstrated by the careful observation of numerous observers, notably by Naunyn, Minkowski, Frerichs-Mankopff, Ziemssen, von Mikulicz, and others. The conclusions here formulated are those of von Mikulicz.

The influence of inflation of the stomach upon tumors of that organ varies with the situation and character of the tumor. Generally, tumors of the anterior wall become more prominent, those of the posterior wall less so. In the former situation the connection of the tumor with the stomach may become plain to sight and touch. If the tumor is massive, it may appear larger and much more prominent. If flat, and not very thick, its boundaries may become less distinct. A single tumor may resolve itself into several tumor masses. The displacement of tumors by inflation varies, also, with the situation of the tumor. Tumors of the pylorus are displaced, usually to the right and downward, more rarely to the right and upward. Tumors of the lesser curvature near the cardia are displaced to the right, beneath the left lobe of the liver. They become less evident or disappear. Tumors of the lesser curvature near the pylorus—a more common site than the preceding—are displaced, sometimes upward, sometimes downward.

Inflation of the colon with air causes the displacement of stomach tumors upward. When the colon is distended, it is usually possible to distinguish a definite outline of tympanitic resonance from the relatively or actually dull percussion note of the tumor, be it of the greater curvature or of the pylorus—

a very useful and important aid in the differential diagnosis between tumors of the stomach and colon.

Tumors of the Colon.—Inflation of the stomach displaces tumors of the transverse colon downward. Inflation of the colon itself may do the same, on account of the increased length of the transverse colon caused by the distention. In cases of tumors of the colon which are producing stricture or partial obstruction, the distention may cease at the level of the tumor, thus demonstrating its position. The direct continuity of a tumor with the colon may also be noted by observing that the distended bowel passes directly into the tumor itself. Inflation of the stomach or bowel displaces tumors of the *omentum* downward. They may also approach the abdominal wall, and thus become more easily palpable. Tumors of the small intestine remain stationary after inflation of the stomach or colon, or if they move, are pressed downward. They are surrounded by the tympanitic area produced by the inflated colon. Tumors of the *liver* and *gall-bladder* are displaced upward by both inflation of the stomach and colon. They are also pressed forward against the abdominal wall.

Tumors of the Spleen and Movable Spleen.—Inflation of the stomach displaces the enlarged or movable spleen to the left, and often a little downward. Inflation of the colon causes displacement to the left and upward. The spleen is pressed toward the abdominal wall, and is more easily palpable. In certain cases the left lobe of the liver, either normal or enlarged, produces a continuous belt of dullness, merging into the dullness of the spleen. An enlargement of the spleen may be eliminated by inflation of the stomach. The distended stomach forces the borders of the two organs apart and gives an intermediate belt of tympanitic resonance.

Tumors of the Kidney.—Inflation of the stomach causes a movable kidney to be less easily palpable. Inflation of the colon pushes a movable kidney upward toward its normal situation, where it usually remains palpable until the colon is fully distended, when the bowel covers it. Large tumors of the kidney, on the other hand, have the colon in front of them, as already noted. Tumors of the liver and spleen override the distended bowel, and within their borders tympanitic resonance gives place to dullness and flatness.

Tumors of the Pancreas.—The usual site for the appearance of a cyst of the pancreas is between the stomach and transverse colon, and unless the cyst is very large or adherent to the abdominal wall, inflation of the stomach or colon tends to cover the cyst wholly or partly, and to render it less evident. Sometimes these cysts may approach the abdominal wall above the stomach or below the colon; only very rarely do they remain behind the stomach and push that organ forward. When they present beneath the left costal border they will be covered by distended stomach or colon, and may readily be mistaken for an enlarged kidney.

(*c*) The Passive Mobility of Abdominal Tumors.—Abdominal tumors can often be moved more or less freely in the belly by the surgeon's hands,

aided sometimes by changes in the attitude of the patient; such that certain groups of muscles are relaxed, the action of gravity brought into play, the tumor made more prominent, more accessible, etc. (See Methods of Examination.) This mobility will vary greatly in different cases. The mobility of tumors will be limited in certain directions by the soft or bony boundaries of the abdomen, by their relations with other organs. Tumors firmly adherent to surrounding structures, or developing in firmly fixed organs, or growing from the abdominal wall or the bony framework of the spine or pelvis, retroperitoneal growths, etc., may show little or no passive mobility; while displaced but normal organs, or tumors, or enlargements of such organs, and tumors of normally very mobile organs, and pedunculated growths of all kinds (unless very large or adherent), show a degree of mobility which varies from a slight sliding movement in one plane to a freedom permitting them to be pushed from one side of the belly to the other, or up and down from the epigastrium to the pubes, or entirely out of reach in the pelvis or beneath the ribs.

The diagnostic value of passive mobility depends upon the general assumption that all organs of the abdomen occupy a definite position which may be regarded as a center around which passive movements take place; and that the extent and direction of such movements is more or less characteristic for the different viscera; further, that enlarged organs or tumors of organs retain this characteristic mobility, or limitation of mobility, more or less perfectly. Among the tumors showing the greatest degree of mobility are tumors of the ovary and uterus possessing a long pedicle; tumors of the omentum, when not close to the transverse colon; tumors of the jejunum and ileum; tumors of the mesentery of the small intestine, when near its insertion in the gut. A movable kidney may occasionally show an extraordinary degree of mobility, such that it can be pushed across the front of the spinal column and well down toward Poupart's ligament; such extreme mobility is, however, rare. Large tumors of the kidney are usually firmly fixed. A mobility of a similar character may, rarely, belong to a movable spleen. Pyloric tumors are often quite movable. Tumors of the pancreas, retroperitoneal growths, of the more fixed portions of the intestine, and inflammatory tumors, show a mobility slight or absent, as the case may be. The diagnostic value of the passive mobility of abdominal tumors was studied and formulated by Pagenstecher, of Wiesbaden (*Deutsche Zeitschrift für Chirurgie*, 1899, Bd. l, Heft 1 u. 2). The following conclusions are taken from his description more or less exactly: He calls attention especially to the fact that mobility of any degree is not characteristic of any particular tumor or organ, but that limitation of mobility in certain definite directions, and to a definite extent, may be very characteristic, indeed, and may define accurately the origin of an intra-abdominal mass. In examining a given tumor the mass must be grasped as well as may be between the hands, or failing this possibility, pushed by the hands and moved in various directions to the limit of its mobility. It will be found that the tumor de-

scribes a more or less definite figure—circular, oval, a curved line, a linear mobility, etc.

Stomach Tumors.—Tumors of the pylorus show the greatest degree of mobility. A similar mobility may be shown by tumors of the greater curvature. The outline of the area over which these tumors can be moved is a circle or an oval of greater or less diameter. Tumors of the lesser curvature may be made to describe a similar figure, but of smaller diameter; and are felt to the left of the middle line, thus differentiating them from the gall-bladder. Tumors near the cardia are seldom palpable.

Tumors of the Large Intestine.—Tumors of the cecum form a mass in the right iliac fossa, movable in the segment of a circle, whose convexity is toward the left, and whose center is the ileo-cecal junction. Tumors of the descending colon and sigmoid flexure exhibit a similar mobility upon the left side, the convexity of the curve through which they move directed to the right. The mobility of the sigmoid flexure varies greatly, according to the length of its mesentery. The mobility of the transverse colon also varies within wide limits. In some cases the gut extends downward in a wide curve toward the pubes, and is then very movable. Tumors of the omentum are freely movable if not near the attachment to the colon, in which case their immobility corresponds to that of the gut. Tumors of the small intestine and of the mesentery near the gut can be moved through a wide circular area.

The Gall-bladder.—Its mobility varies greatly. When contracted and tucked up under the liver it is usually out of reach, and may be immovable even on direct palpation through a wound. When it extends well below the border of the liver, and can be felt, it can be moved directly backward. In some cases from side to side, through usually only a flat and narrow arc. When very long its mobility may be considerable, through a circular or oval area, the center of motion being its attachment to the liver.

Spleen.—A movable spleen may sometimes be moved across the middle line of the abdomen from left to right. If doubt exists as to whether the organ is spleen or kidney, inflation of the large intestine will cause the kidney to disappear behind the distended gut. The spleen will remain at the front of the belly, although displaced upward, and lying as it does in front of intestine, will become more prominent.

The Kidney—Movable Kidney.—Pagenstecher distinguishes three grades of mobility: First grade, the lower pole of the kidney only, projects below the ribs, and is there palpable; the only passive motion possible is to push it upward toward its normal place. In the second grade of mobility the kidney may be grasped between the hands and moved up and down or through a considerable arc; the hilum remains directed toward the center of motion—i. e., its vascular attachments to aorta and vena cava. In the third grade of mobility the kidney may be moved across the spinal column to the other side of the abdomen. Its hilum remains directed toward the center of motion, as in class 2.

Henry Morris distinguishes also three grades of mobility, as follows: [1]

(1) When the kidney moves up and down so that its lower half comes between the grasp of the examining hands (combined lumbar and abdominal palpation) during deep inspiration. (2) When the greater part, or even whole, of the kidney can be grasped during a deep inspiration, but ascends again during expiration. (3) When the whole kidney descends below the examiner's fingers and can be retained below them after the patient makes a full expiration. In some of the more extreme cases the kidney is often out of position during natural respiratory movements. The peritoneum may be sufficiently loose to allow the kidney to fall below the brim of the pelvis, or against the anterior abdominal parietes, or across to the opposite side of the spinal column, moving through a circle with a diameter of eight or nine inches.

When the kidney becomes enlarged from the presence of a tumor or inflammation it usually descends somewhat, but does not usually become more mobile. As stated, large tumors of the kidney, whether malignant or inflammatory, are, as a rule, firmly fixed. In examining for movable kidney it is a good plan to place the patient on her back with the knees drawn up and the feet supported below, and while one hand on the loin presses forward the free ribs, to palpate deeply below the costal arch in front with the other, at the same time telling the patient to take a deep breath. Since most of these patients are slender or flabby women, the kidney can usually be felt quite plainly to descend beneath the fingers of the anterior hand during deep inspiration and to slip away again during expiration. If this method fails, the patient may be turned on the sound side with a cushion under the loin, the knees and thighs a little flexed; bimanual palpation is then made. The kidney may also be sought for by having the patient lean forward while a nurse supports the arms and shoulders from in front; palpation during deep inspiration may then be made. There remains examination under a general anesthetic to be tried if other methods fail. Very freely movable kidneys can usually be felt with great ease. By their shape and behavior, as indicated, they are easy to identify.

Tumors of the Ovary and Uterus, when not so large or so adherent as to be immovable or impacted in the pelvis, can be moved upward in the abdomen away from their point of attachment; at the same time a finger in the vagina upon the cervix can usually feel that the tumor gives the uterus a distinct tug. Laterally, such tumors may be moved through a more or less flat arc, whose center is the pelvic attachment of the tumor. In all pelvic tumors of doubtful character it is well to listen for fetal heart sounds, for a placental bruit, and to seek with one or two fingers against the cervix for ballotement.

Mobility of Tumors of the Abdominal Wall.—Nonadherent tumors in the subcutaneous tissue may be moved as in other situations. Tumors attached to the muscular wall of the abdomen and inflammatory tumors of the abdom-

[1] Henry Morris, "Surgical Diseases of the Kidney and Ureter," vol. i, page 103. London, Cassell.

inal wall take part in the muscular movements of the belly. Putting the bel upon the stretch by muscular contraction renders them immovable.

Advantage may sometimes be taken of gravity in examining tumors of t abdomen. The genu-pectoral position often renders an enlarged gall-bladc more easily palpable, or causes a pelvic tumor to rise out of the pelvis and readily felt. The introduction of a tubular speculum into the vagina or rectu in this position permits the viscera to fall upward and the vagina or rectu to be distended with air. The presence of inflammatory or other infiltratic in the pelvic viscera or pelvic floor renders these structures immovable, a immobility or bulging of the posterior fornix of the vagina or the wall of t rectum may often be readily detected by sight.

CHAPTER II

SURGICAL DISEASES OF THE STOMACH

PYLORIC STENOSIS

Narrowing of the pyloric orifice of the stomach occurs as a chronic and usually progressive condition. Acute obstruction is relatively rare. In the chronic cases the obstruction is not complete except as a terminal condition just before death. In most instances inanition terminates life before total occlusion is developed. Clinically, we are unable to distinguish pyloric stenosis from narrowing of that portion of the duodenum above the papilla of Vater.

Causes.—Congenital narrowing of the pylorus is observed as a rare condition. In the acquired form the causes may be intrinsic or extrinsic. The former are cicatricial contraction, following ulcers of the pylorus or immediate vicinity; either peptic ulcers or, much more rarely, such as follow cauterization of the stomach by caustic liquids swallowed. Stenosis may occur after healing or in the presence of one or more ulcers. Chronic inflammatory thickening of the pylorus may cause stenosis without ulceration. Tumors of the pylorus, nearly always carcinomata, are a frequent cause. Impaction of foreign bodies in the pylorus a rare cause. The so-called pyloric spasm due to nervous causes is believed to exist. It is usually associated with atony of the muscular wall of the stomach. Extrinsic causes are chronic adhesive peritonitis, with the formation of bands or massive adhesions between the pylorus and the liver, gall-bladder or colon, causing traction upon and loss of mobility of the pylorus, and consequent angulation or kinking, and thus continuous or intermittent stenosis. Such angulation is often formed at the junction of the fixed with the movable portion of the duodenum, and is increased by the descent of the dilated stomach, the two factors reacting one upon the other to render the angulation of the pylorus worse. Pressure from without—by tumors in the vicinity, true neoplasms, or chronic inflammatory tumors or exudates—syphilitic, tubercular, or simple inflammatory—as from masses of retroperitoneal lymph nodes pressing on the duodenum, or the lymph-node tumors of Hodgkin's disease.

Associated Lesions.—Stenosis of the pylorus is commonly associated with dilatation of the stomach and a train of local and general symptoms about to be described. In a few cases, by diminution in the size of the stomach; this latter condition occurs when a large part of the wall of the stomach is in-

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filtrated by a new growth, usually a carcinoma, a part of the lesion being stenosis of the pylorus. (See Tumors of the Stomach.) The cases of pyloric stenosis with dilated stomach, accompanied by carcinoma of the pylorus or open peptic ulcers, will exhibit symptoms modified to a greater or less extent by the presence of these additional lesions. They will be separately described. We shall here consider cases in which the imperfect escape of the chyme into the intestine constitutes the essential causative factor of the disease. In these cases progressive dilatation of the stomach occurs, often accompanied by hypertrophy of the muscular wall, followed at length by atrophy of the mucous membrane, and finally by atrophy of the muscular coat. As a part of the lesion chronic gastritis develops —more marked in cases complicated by ulcer and carcinoma of the stomach.

FIG. 15.—MARKED DILATATION AND DESCENT OF THE STOMACH FROM CANCER OF THE PYLORUS. (Kindness of Dr. Walter James.)

The cause of the increase in size of the stomach is that, owing to the mechanical obstruction at the pylorus, the stomach does not empty itself properly, and is continually overloaded and distended by food and liquid swallowed (motor insufficiency). At first the motor insufficiency causes merely a delayed emptying of the organ. Ten or twelve hours after eating, as on rising in the morning, the stomach, upon the introduction of a stomach-tube, will be found empty. Later, as the disease progresses, the degree of insufficiency reaches a point such that the stomach never empties itself naturally. Upon passing a stomach-tube in the morning, nothing having been eaten since the evening meal of the night before, the stomach will still be found to contain food, not only the food of yesterday, but in some cases of days before. When this stage is reached, no matter what the causative factors may have been (if we except the dilated stomach sometimes accompanying diabetes), the case becomes one of surgical rather than medical interest. Such a stomach is not likely to regain its motor power unaided by gastro-enterostomy, or such other surgical procedure as is suited to the particular case. It is, of course, understood that many cases demand surgical interference, in the presence of ulcer, carcinoma, or other serious lesion before this stage is reached. Important also in deciding the question of surgical interference is the progressive character of

the disease, failure to respond to medical treatment, gastric lavage, etc., and marked disturbance of the general nutrition.

Symptoms and Signs of Stenosis of the Pylorus with Dilated Stomach.—The local and general symptoms and signs of stenosis of the pylorus with dilated stomach are as follows: The patient suffers from the symptoms of gastric dyspepsia. He has a sense of epigastric distention and distress after taking food; in bad cases only relieved by vomiting or emptying the stomach by a tube. There is loss of appetite, pyrosis, a coated tongue, a bad taste in the mouth, often a foul breath, and belching of gas from the stomach. Acute pain after eating may or may not be present; it is regarded by some observers as suggestive of ulcer or of malignant disease rather than simple stenosis. Owing to the fact that fluids swallowed pass beyond the stomach only in small quantities, and that the stomach does not readily absorb water, even under normal conditions, and that the dilated stomach secretes often a considerable quantity of fluid, there is continued annoying thirst. There may be diffuse tenderness over the stomach, usually not the circumscribed tenderness over the pylorus common in ulcer and carcinoma. The intermittent peristaltic waves and hardenings of the stomach wall, to be described, are sometimes accompanied by sharp spontaneous pain.

Nausea and Vomiting.—Nausea and vomiting are regularly present. The vomiting varies greatly in frequency, and to some extent, also, in character, depending upon the intensity of the accompanying gastritis and degree of dilatation of the stomach. Frequent vomiting occurring, even though the stomach be empty, indicates a marked gastritis, and is suggestive of carcinoma or open ulcer. Vomiting due to distention of the stomach with food occurs less frequently, once a week, once in two or three days, or once a day, then usually upon rising in the morning. A characteristic of this variety of vomiting is that the quantity is often very large, and that in the vomited material there are to be recognized particles of food taken the day before or several days before. To relieve the distress accompanying the distended condition of the stomach many of these patients get into the habit of inducing vomiting at intervals by tickling the back of the pharynx with the finger. Examination of the vomited matters may give valuable diagnostic aid. By a gross examination, the quantity, odor, presence of ancient food particles, of mucus, pus, or blood in considerable amounts may be detected. The amount and character of the acidity are determined by chemical means. The microscopic appearances include search for pus, blood, tumor fragments, bacteria, yeast, sarcinæ, etc. (See section on Examination of Stomach Contents, etc.)

Anomalies of Secretion and Other Changes in Stomach Contents Accompanying Pyloric Stenosis.—It is exceptional that a positive diagnosis of the nature of the lesion causing pyloric obstruction can be based upon the results of gastric analysis alone. In some cases the data are strongly confirmatory of the conclusions based upon the symptoms and physical signs; in others they are not. In some cases the obstructed stomach falls at once into

an atonic state with progressive atrophy of both mucosa and muscular wall; in others compensatory hypertrophy of the muscularis is associated with an increased activity of the secreting glands of the mucous membrane, followed by subsequent atony and atrophy of the entire stomach wall as the dilatation becomes extreme. These conditions are accompanied by a chronic gastritis, also of variable intensity. In general, it may be said that marked chronic gastritis is often associated with ulcer and with carcinoma; that hyperacidity is usually present with ulcer; that absence of free HCl is often to be observed in cancer; but that an increased amount of acid does not necessarily indicate the presence of an ulcer nor is normal acidity incompatible with carcinoma. Entire absence of HCl may be due to mere atonic dyspepsia even without the presence of stenosis, and is a common condition in many cases of dilated stomach, associated with atony early in the disease; and is regularly present in cases of extreme dilatation with atrophy when the condition is far advanced; in such cases the stomach may cease to be a secreting organ (achylia).

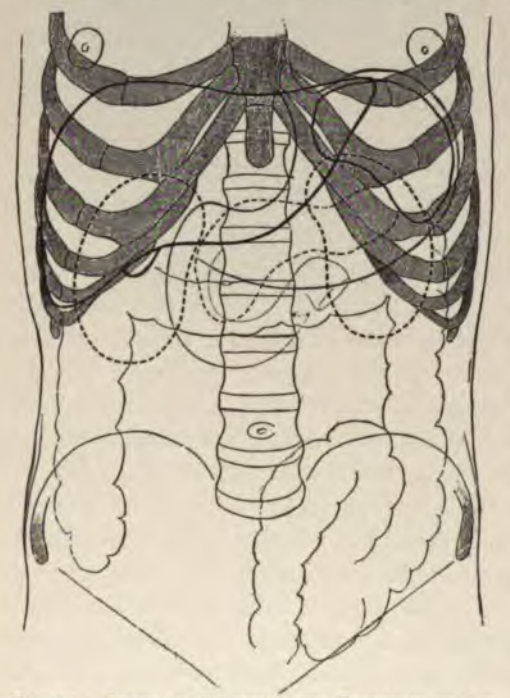


FIG. 16.—DIAGRAM SHOWING THE POSITION OF THE MOST IMPORTANT ABDOMINAL VISCERA ANTERIORLY. Large intestine, kidneys, pancreas, spleen, and stomach. (After Merkel.)

In uncomplicated cases of stenosis—i. e., with neither ulcer nor carcinoma—the amount of secretion is often increased, with increased, normal, or diminished acidity. The quantity of gastric secretion may be very large, so that, for example, upon giving such a patient a test breakfast, his stomach being empty, an amount of fluid will subsequently be withdrawn by siphonage greatly in excess of that introduced. When the stenosis and motor insufficiency have reached such a grade that the stomach no longer empties itself over night, HCl will usually be diminished, and the retained stomach contents will rather rarely, except in the presence of cancer, undergo lactic-acid fermentation. If the amount of HCl remains considerable, yeast fungi and sarcinæ will usually be present, and the fermentation will be of a corresponding type. The bacterial content of the stomach is regularly increased in all cases where complete or partial stagnation of stomach contents occurs. (For further details, see section on Stomach Contents below.)

Certain physical signs are present as the result of dilated stomach; some of them have been sufficiently dwelt upon in the preceding pages. (See Diagnois

of Abdominal Tumors.) Here may be added that along with dilatation descent of the stomach regularly occurs; the cardiac orifice remains fixed.

Anatomical Notes.—The position of the cardiac orifice in the average case is behind the articulation of the seventh or eighth costal cartilage with the left border of the sternum (see diagram from Merkel). The pylorus, whose position is normally the most constant of any portion of the stomach, lies opposite the upper right-hand corner of the body of the first lumbar vertebra. Its position in reference to surface landmarks may be determined by dropping a vertical line from the right sterno-clavicular joint downward to a point opposite the umbilicus. The junction of the lower two fifths with the upper three fifths of this line corresponds to the position of the pylorus (G. S. Huntington). Normally the pylorus lies beneath the border of the liver and cannot be palpated. In cases of dilated stomach the pylorus descends to some extent. If a considerable tumor is present in it, or if it is notably thickened by inflammatory infiltration and the patient is thin, it can be felt to the right of the median line at a somewhat variable distance below the border of the liver; and, as already stated, shows usually some respiratory mobility, and a degree of passive mobility, which varies from very free to more or less complete fixation, on account of adhesions to liver, gall-bladder, or other structures. In very thin subjects it is alleged that the pylorus, even when but slightly thickened, can be recognized by palpation as a mass which undergoes alternate hardening and relaxation.

FIG. 17.—DIAGRAM SHOWING THE MOST IMPORTANT ABDOMINAL VISCERA VIEWED POSTERIORLY. The lesser curvature of the stomach and the duodenum. The ascending and descending colon. The spleen, the liver, and the kidneys.

BUBBLING SOUNDS AND SENSATIONS.—Another sign usually recognizable in pyloric stenosis from any cause, unless the abdominal wall is quite thick, is the sensation transmitted to the examining hand as bubbles of gas pass through the narrowed orifice, or as a sound heard through a stethoscope loudest over the pylorus. It can only be described as a sensation as of passing bubbles, but is yet not difficult to appreciate and quite characteristic. In regard to palpation of the not thickened pylorus, William Osler ("The Diagnosis of Abdominal Tumors," page 37, 1898) makes the following statement:

> I believe that in very thin-walled persons, particularly those with atony of the stomach, the pylorus—i. e., the ring and adjacent part—may sometimes be felt as a narrow, tubular structure, the distinguishing features of which are the alternate relaxation and contraction and the bubbling of gas through it.

The level of the greater curvature varies, under normal conditions, within rather wide limits, according to the degree of distention of the organ with food, etc. An average position in health corresponds to a line drawn across the abdomen through the lowest points of the cartilages of the ninth rib.

Peristaltic Waves and Intermittent Rigidity of the Stomach Wall.—As already stated under Diagnosis of Tumors of the Abdomen, visible peristaltic waves in the stomach wall are practically pathognomonic of pyloric stenosis; they are scarcely to be seen under other conditions, except faintly in some very emaciated subjects. In cases of dilated stomach they are absent when the muscular wall is atonic—i. e., in a considerable proportion of cases. When present, the waves occur every few seconds, either spontaneously or as the result of cutaneous irritation, or may be induced by kneading the stomach. They usually proceed from cardia toward pylorus, rarely in the opposite direction. (See Diagnosis of Tumors of Abdomen.)

Fig. 18.—A Photograph of the Empty and Contracted Stomach of a Man who was Executed at Sing Sing Prison for Murder. The extreme muscular spasm is well shown, as also the much greater development of the muscular layers of the stomach in its pyloric third. The shape of this stomach is exactly as it appeared at autopsy. (Kindness of Prof. George S. Huntington.)

A spasmodic contraction of the muscular wall of the stomach—usually near the seat of the obstruction, sometimes elsewhere—visible as a localized bulging of the abdominal wall and palpable as an indurated area of variable size, which lasts a few seconds, and then subsides, or passes on into a wave, again to remain for a moment as a bulging in a new place, and again to subside, is a sign present in some cases of dilated stomach, usually those with marked hypertrophy of the stomach wall. The sign is less common than are the visible peristaltic waves. When present it is characteristic.

Succussion Sounds.—Splashing sounds elicited by agitation of the stomach may be present when the normal stomach contains fluid and gas. The diagnostic value of the sign lies in the fact that in cases of dilated stomach the succussion sounds persist at times when the stomach should be empty.

Fig. 19.—The Empty Stomach of a Man who Fell from the Roof of a Tall Building and was Instantly Killed. The accident happened early in the morning. The victim had had no breakfast. The shape of this stomach is exactly as it was when removed at autopsy. Again the muscular development of the pyloric portion of the stomach is well shown. (Kindness of Prof. George S. Huntington.)

Disturbances of General Health in Pyloric Stenosis.—Well-marked pyloric obstruction from whatever cause has a profound effect upon the general nutrition. The patients suffer from gradual starvation, and notably from diminution of the body fluids. They become weak and emaciated, and acquire a peculiar wizened appearance. The skin of the back of the hand or of the abdominal wall lifted up into a fold tends to remain wrinkled for several seconds. The quantity of urine passed is diminished and of a high specific gravity. There is marked constipation of the bowels, and annoying persistent thirst. Owing to the small amount of water entering the circulation, the blood takes part in the general drying process, and therefore the hemoglobin may appear to be normal in amount, notwithstanding the miserable condition of the patient. In the given case operation is indicated: (1) When the evidences of motor insufficiency are well marked and fail to disappear under gastric lavage, diet, etc.; (2) when the general health suffers seriously; (3) when cancer is suspected; (4) when stenosis is associated with the symptoms of ulcer of the stomach.

Fig. 20.—Stomach Removed at Autopsy of a Man who Died Suddenly after a Moderately Full Meal. The shape of the stomach is exactly as it was when removed from the body. The muscular part of the stomach—namely, its pyloric third—is well shown. (Kindness of Prof. George S. Huntington.)

The diagnosis of carcinoma of the stomach and of gastric ulcer are described in other sections.

Conditions Simulating Organic Pyloric Obstruction.—Here may be mentioned two conditions simulating organic pyloric obstruction: (1) Pyloric spasm upon a neurotic basis and (2) hour-glass contraction of the stomach.

1. Pyloric Spasm.—Pyloric spasm is very rarely associated with *marked dilatation* of the stomach and its accompanying physical signs; other marked evidences of a neurotic temperament are sure to be present. Assuming that mere pyloric spasm is associated with a degree of motor insufficiency, such that serious disturbance of the general health ensues, the surgical indications are the same for these as for cases of organic obstruction.

2. Hour-glass Deformity of the Stomach, Sacculated Stomach.—This rather rare condition has been observed as a congenital deformity in a few instances, but is less frequent than congenital pyloric stenosis. Hirsch and Terret were able to collect twenty cases believed by them to be of this character. Other observers, among them Moynihan, consider the existence of this deformity as a congenital condition doubtful; and believe that in cases producing recognizable symptoms an ulcerative process of the stomach wall has always preceded the deformity of the stomach. In the acquired form, ulcer of the stomach is the regular causative factor, and operates in two ways: the cicatricial contraction of the stomach wall following the healing of an extensive ulceration produces an actual narrowing of the caliber of the stomach over a definite area, upon either side of which mechanical distention, gravity, and muscular action cause sacculation and the formation of two separate loculi in the stomach, connected by a narrower isthmus. It is probable that this method of formation is usually combined with another factor—i. e., as the result of slow ulceration—a peritoneal irritation and adhesive peritonitis of the stomach surface causes agglutination of the stomach to the anterior abdominal wall, to the pancreas, or other peritoneal surface, depending upon the site of the ulcerative process. The stomach thus becomes anchored over some portion of its surface and fixed. The former factors mentioned come into play and cause a separation of the stomach into two sacs of unequal size. The constriction may take place anywhere between the cardia and the pylorus. A similar deformity may be caused by malignant disease of the stomach.

When the constriction is near the esophagus and the cardiac sac is small, the symptoms will resemble those of cardiospasm, or of stricture of the lower part of the gullet with dilatation above the stricture. When the constriction is near the pylorus, the signs and symptoms closely resemble those of pyloric stenosis. In that form furnishing the most characteristic signs and symptoms the constriction forms somewhere near the middle of the stomach, so that two, or even three, sacs exist, each of considerable size, though one or other is usually larger.

Certain diagnostic signs exist in cases of hour-glass stomach, such that the clinical diagnosis is usually possible. The most characteristic are the following:

1. If the stomach-tube is passed and the stomach washed out with a measured quantity of water, the amount withdrawn will be notably less than that introduced (Wölfler's "first sign").

2. If the washing of the stomach be continued until the water returns clear, regurgitation may suddenly take place from the distal into the proximal pouch, and a quantity of dirty foul-smelling fluid may appear in the funnel; or if the stomach be washed clean, the tube withdrawn, and reintroduced, after a few minutes, renewed washing may furnish an unexpected quantity of foul material.

3. The sign called by Jaworski "paradoxical dilatation"—i. e., the presence of succussion—splashing sounds having been elicited in the stomach by palpation, the stomach-tube is introduced and the stomach emptied. Succussion sounds may still be obtained, since some of the fluid from the pyloric pouch will regurgitate into the cardiac compartment.

4. In some cases it has been possible by inflating the stomach to detect a visible constriction in the dilated organ and a bulging upon either side of the constriction.

5. In a few cases the following sign has been observed (von Eiselberg): The stomach is filled with water through a tube. A distinct bulging has been observed to the left of the median line. After a few minutes this prominence has subsided, and a similar bulging has been observed farther to the right.

6. A Seidlitz powder is administered, the two powders being given separately. The stomach immediately becomes distended; upon applying a stethoscope to the abdominal wall a bubbling, gurgling sound will be heard, loudest to the left of the median line. In normal cases, or in stenosis of the pylorus, this sound will be heard loudest to the right of the median line over the pylorus (von Eiselberg).

7. Ewald regards the following sign as of value: Water is introduced into the stomach, and its interior illuminated by gastrodiaphany; the cardiac pouch alone is illuminated, the pyloric pouch remains dark.

When the constriction is very near the cardia, the symptoms of immediate regurgitation of food may resemble stricture of the gullet at the cardia or cardiospasm. The introduction of a bougie will meet with no obstruction until a point is reached beyond the normal distance from the teeth to the cardia—sixteen inches (Moynihan). When the constriction is close to the pylorus, the symptoms will be those of dilated stomach and pyloric stenosis. The detection of two compartments can best be made by Wölfler's two signs, as described.

ACUTE OBSTRUCTION OF THE PYLORUS AND DUODENUM

Acute complete closure of the pyloric orifice of the stomach is, compared with chronic stenosis, an exceedingly rare condition. Of more frequent occurrence, though still rare, are cases of acute obstruction of the duodenum. The latter may occur in two situations—at the junction of the movable with the

fixed portion, or farther down where the duodenum is crossed by the superior mesenteric artery.

Acute Dilatation of the Stomach.—Obstruction at any of these points is regularly associated with acute dilatation of stomach. No cases of complete obstruction of the pylorus by foreign bodies swallowed or by impacted gall-stones have been observed as far as I am able to learn. As a great surgical rarity may be mentioned volvulus of the stomach with complete obstruction, both at the pylorus and cardia, and enormous dilatation of the organ. Following operations upon the biliary passages and liver, complete obstruction of the duodenum by the pressure of gauze packings introduced for drainage or the control of bleeding has been observed in a number of cases. The symptoms have been continued vomiting and great distention of the stomach. In some cases these symptoms ceased after the packing was removed.

Anatomical Sites and Mechanism of Duodenal Obstruction.—As stated, obstruction of the duodenum may occur in two situations: At the junction of the movable with the fixed portion, and at a lower point where the duodenum is crossed by the superior mesenteric artery. In the first class of cases the obstruction is in the nature of an angulation. It would seem probable that the condition would be more apt to occur in cases of general enteroptosis. The weight of distended, overloaded stomach, aided sometimes by external pressure, such as might be caused by tight lacing, a plaster-of-Paris jacket too tightly applied, etc., caused the organ to sag downward, dragging pylorus and duodenum after it; angulation at the junction of the free with the fixed portion of the gut is thus produced and complete obstruction at this point. In the second class of cases the coils of small intestine fall, or are pressed, downward by a distended stomach into the pelvis, traction upon the mesentery puts the superior mesenteric artery upon the stretch in such a manner that the duodenum is compressed between this vessel and the aorta and its caliber occluded.

Signs and Symptoms of Acute Dilatation of the Stomach.—The signs and symptoms of these forms of obstruction are rapid and usually enormous dilatation of the stomach with paralysis of its muscular wall. The organ may fill the entire abdomen and extend to the pubes. Vomiting, abdominal distention, pain, dyspnea, prostration, and the physical signs of a dilated stomach are present. In cases of obstruction of the lower portion of duodenum the vomited matters would contain bile. Unless relieved, the condition ends in death from starvation or exhaustion. The introduction of a stomach-tube renders the diagnosis clear, and aided by elevation of pelvis, the genu-pectoral position, inversion of the patient in case of children, usually overcomes the obstruction and relieves the distended stomach (see Figs. 6, 9, and 15).

CONGENITAL STENOSIS OF THE PYLORUS

A rare condition. A moderate number of cases have been reported during recent years. The narrowing may be an actual congenital stricture or may

depend upon hypertrophy of the muscular ring of the pylorus, so that it may form a palpable tumor. The symptoms may develop at once or very soon after birth, or may be delayed for a number of months. In the worst cases the infants die speedily of continued vomiting and inanition; dilatation of the stomach has not time to develop. In cases developing at a later period, or less severe, frequent vomiting, fermentative changes in the vomited matters, evidences of motor insufficiency of the stomach, determined by the use of the stomach-tube, as in adults; emaciation and marasmus, sometimes with the signs of dilated stomach, establish the diagnosis. It is to be borne in mind that in milk-fed infants free HCl is not found in the gastric secretion.

ULCER OF THE STOMACH

Characteristics of Ulcer.—Ulceration of the wall of the stomach occurs as an independent lesion in the form of the ordinary acute and chronic ulcer of the stomach, peptic ulcer, round ulcer, and is characterized by certain marked peculiarities. In a certain proportion of cases the ulcer is suddenly formed and runs an acute course, ending in spontaneous recovery, or in serious hemorrhage, or in perforation, or, in other instances, remains and becomes a chronic ulcer. In some cases the ulcer is but slowly formed and appears to run a chronic course from the start. Clinically, the distinction between acute and chronic ulcer of the stomach is important, since the former rarely requires surgical treatment; the latter, on the other hand, is in most cases only curable by surgical means. The ulcer is usually round or oval in shape, sometimes irregular in outline. More than one ulcer exists in a goodly proportion of cases. The process may involve destruction of the mucous membrane merely, or may perforate the entire thickness of the stomach wall. It may be of any size from a pin's head to several inches in diameter. Upon inspection, when the ulcer invades the muscular wall, it will be found somewhat funnel-shaped or terraced. In some acute cases it appears as a mere fissure only visible in the mucous membrane on stretching the stomach so as to obliterate the rugæ of the mucosa.

In acute or recent cases little or no evidence of inflammatory action is observed in the edges or base of the ulcer. Upon removal from the body, a stomach containing such an ulcer may look as though some portion of its wall had been removed mechanically with a circular punch. In chronic cases the margin and base of the ulcer may show marked inflammatory thickening and induration to the extent of producing a considerable tumor mass. A differential diagnosis from carcinoma may be impossible in these cases from the macroscopic appearances. The condition of the remainder of the stomach varies. In acute cases, it may appear normal or hyperemic or show the lesions of chronic gastritis. In chronic cases, the lesions of chronic gastritis will usually be present. When associated with pyloric stenosis and dilated stomach, hypertrophy or atrophy of the muscular wall of the stomach will be found, according to the stage of the process and the degree of gastric dilatation. Ex-

tensive cicatricial deposits in the wall of the stomach may be found in ca where former ulcers have existed.

Peptic ulcers are found only in that portion of the alimentary tract wh its contents are normally acid—in the stomach, at the cardiac end of the gull and in the first portion of the duodenum as far down as the orifice of t common duct, after the operation of gastro-enterostomy, occasionally in t jejunum. Hyperacidity is a regular accompaniment of gastric ulcer, as pyloric spasm and motor insufficiency. But it must be said that the ex relations of cause and effect between these associated conditions is not entir clear. Some changed condition in the nutrition of the mucous membrane the stomach over the affected area is present, such that it becomes suscepti to the action of the gastric juice; more than this it is scarcely possible to s Peptic ulcer of the jejunum was observed by von Mikulicz after anter gastro-enterostomy in an infant aged three months (among babies at that a free HCl is either absent or weak). It is much less likely to follow pylo plasty and posterior gastro-jejunostomy with a short loop.

Statistics of Gastric Ulcer.—Gastric ulcer is a very frequent and a very fa disease. Statistics would seem to indicate that nearly twenty-five per cent of b acute and chronic ulcers of the stomach, taken together, untreated surgical are fatal. Of these, six per cent die of perforation; eight per cent, of hem rhage; chronic cases are not infrequently followed by carcinoma of the sto ach, and a pretty large number die of phthisis. The disease is twice as f quent in women as in men. (Upon this point the statistics of differ observers vary a good deal.) In women it occurs most often between the a of fifteen and thirty-five years, and is most common at or about the twenti year of life. It is rare in either sex during childhood. In men it occ usually between the ages of thirty to forty-five years. The following statist are those given by von Mikulicz and Kausch: The most frequent seat of g tric ulcer is upon the posterior wall along the pyloric half of the lesser cur ture. Four fifths of the ulcers occur in this vicinity; forty per cent oc in the posterior wall of the body of the stomach; twenty-five per cent in pyloric portion and in the pylorus; fifteen per cent on the lesser curvat itself. The remaining twenty per cent are distributed over the remain of the stomach. Only one ulcer in twenty occurs upon the anterior wall, a yet perforation takes place much more often here than elsewhere; at le seventy-five per cent of all perforations are found to be in this situation.

Perforation.—Perforation of gastric ulcer may occur suddenly or gradua with results which are modified according to the anatomical site of the ulc Sudden perforation into the general cavity of the peritoneum with the esc of a considerable quantity of stomach contents produces peritoneal sepsis diffuse purulent peritonitis. This fatal accident is more apt to occur wl the perforation takes place through the anterior wall of the stomach. T active mobility of the anterior abdominal wall on the one hand, and of stomach on the other, tends to prevent sealing of the orifices by adhesio

The occurrence of perforation may be entirely spontaneous. It may, on the other hand, follow indiscretion in diet, an alcoholic debauch, or the like, or may be the immediate result of traumatism from without; such trauma may be slight.

A more gradual invasion of the peritoneum occurs when the perforation is very small or when adhesions have time to form between stomach wall and adjacent structures. If these latter are inadequate, and leakage finally takes place, there will result a progressive fibrino-purulent peritonitis, or a localized perigastric abscess. In other cases massive adhesions will be formed about the stomach, resulting in deformity of the organ (hour-glass contraction), or stenosis of the pylorus, from cicatricial contraction of its orifice or from angulation. In some cases there will result pain and functional disturbances of digestion of any degree of severity due to mechanical interference with the mobility of the stomach. If the perforation takes place along the lesser curvature or into the lesser sac a left-sided subphrenic abscess is a very common result. Perforation through the diaphragm has been observed with septic pleuritis, mediastinitis, abscess of the lung, etc. If adhesions are formed between stomach and pancreas or liver the ulceration may extend into the substance of these organs; by a similar process large blood-vessels may be invaded—the arteries of the pancreas, vena cava, splenic vessels, etc., very rarely the spleen itself. Perforation into duodenum or transverse colon produces an internal fistula. In rather rare cases perforation occurs through the anterior wall of the stomach in an area adherent to the abdominal wall. Gradual perforation of the abdominal wall may result with the formation of an abscess opening outwardly and a fistula. In these cases the physical signs may be those of an inflammatory process of the belly wall merely, and unless a history of gastric disturbances, bleeding, etc., are obtained, an error in diagnosis is quite apt to be made.

Hemorrhage.—In about half the cases of gastric ulcer bleeding occurs from the eroded vessels in such amounts as to cause definite symptoms—vomiting of blood (hematemesis) or the passage of black tarry blood with the stools (melena). The bleeding may occur as the result of erosion of one of the four large arteries of the stomach—coronary, right or left gastro-epiploic or pyloric, occasionally from the vena cava or other large vessel invaded in the course of the disease. The most frequent source of serious hemorrhage of this kind is a large arterial trunk running in the substance of the pancreas, for this organ is more often invaded by penetrating gastric ulcer than any other. Such bleeding is usually severe, often lethal. In other cases the small vessels of the stomach wall are the source of blood; in these the hemorrhage may occur as a single attack or be repeated at longer or shorter intervals. The appearance of the vomited blood will vary according to the time it has remained in the stomach. If subjected for a considerable time to the action of the gastric juice, it will be dark in color, "coffee-ground" vomiting; if large in amount and speedily expelled, it will be pure blood; occasionally the vomited matter will simply be streaked with blood. Profound, acute, or chronic anemia becomes

thus one of the commonest complications of gastric ulcer; it may assume pernicious type, and the markedly anemic state into which many of th patients fall renders them susceptible to intercurrent infections, notably phthisis, as already mentioned, and many die of this disease. Moynihan lieves that the bleeding from gastric ulcer may be classified under two types i. e., hemorrhage from acute and from chronic ulcer. The classification practical in that it furnishes a basis for valuable operative indications.

Characteristic of acute ulcer are the sudden, spontaneous occurrence o large hemorrhage from the stomach without any antecedent history point to gastric disturbance. There is a rapid loss of a large amount of blood an tendency for the bleeding to cease spontaneously and not to recur except small, insignificant amounts. In these cases vomiting of blood in large amo or the passage of a large, tarry movement is preceded by the symptoms of ac anemia, sudden in their occurrence and profound, though quickly recove from. At the time of the hemorrhage the patient becomes suddenly pale a weak, with a rapid, thready pulse; the respiration is sighing or shallow a rapid; the extremities cold and pale, and the general cutaneous surface batl in clammy sweat. The hemorrhage is rarely repeated, and the patients impro to develop the symptoms of chronic ulcer or, in some cases, to get well.

Moynihan's Classification of Hemorrhage from Gastric Ulcer Hemorrhage from chronic ulcer—Moynihan has been able from the observat of his cases to divide them into four groups: (1) The hemorrhage is so sm in amount as to escape observation without repeated microscopic and mic chemical examination of the stomach contents and feces. (2) Repeated he orrhages occur at irregular intervals, usually of several months. The amo of blood lost is considerable at each. The patients have marked disturban of gastric digestion; they become notably anemic. (3) Hemorrhages con erable in amount and *frequently repeated* occur in an individual who has l suffered from gastric disturbance. The bleeding is severe enough to prod marked acute anemia, and recurs after hours or days, threatening speedy dea (4) The bleeding occurs from one of the main arterial trunks of the stoma from the vena cava, the splenic artery, or other large vessel eroded during progress of the ulcer. Such bleeding is sudden, continuous, and uniform fatal.

Moynihan believes that operation is indicated in cases of acute ulcer o in the somewhat rarer cases, when repeated bleeding threatens life or seriou impairs the patient's strength. In cases of chronic ulcer operation is indicat especially in class three—i. e., where repeated bleeding occurs in an individ long the subject of gastric dyspepsia. The operation of gastro-enterostomy l fulfills the indications. Only occasionally is search for the bleeding ve in the stomach successful.

Cases without Hemorrhage.—There remain a considerable number of ca the subjects of chronic ulcer, not accompanied by bleeding, in which the sy toms are those of chronic dyspepsia, accompanied by motor insufficiency

the stomach due to pyloric spasm or to actual narrowing of the pyloric orifice by cicatricial contraction or thickening, and by a dilated stomach of a more or less marked grade. In some cases the entire pyloric portion of the stomach appears to be in a state of abnormal contraction. In others the pylorus and the first portion of the duodenum are dilated; the obstruction exists in the second portion of the duodenum opposite the entrance of the common duct, and is accompanied by hypertrophy of the muscular coat of the duodenum at this level (Ochsner). Another variety of interference with gastric mobility is the condition of valve formation, in which a high-placed pylorus is dragged upon by a short gastrocolic omentum (W. J. Mayo). These conditions are often associated with gastric ulcer, whether as a cause or as an effect is not clear. In many cases of gastric ulcer profound disturbances of the general health occur from malnutrition, from pain, stagnation of stomach contents, etc. The symptoms produced are due to mechanical causes, and are sometimes completely relieved by gastro-enterostomy.

It is to be borne in mind that operations upon the stomach for the direct control of bleeding from a gastric ulcer are usually difficult, often impossible of fulfillment. Assuming that the ulcer is found and the bleeding controlled, the preëxistent conditions predisposing to ulcer are not relieved, the mechanical conditions remain the same. In many cases of acute ulcer no sign will be present on the peritoneal surface of the stomach to serve as a guide to the seat of the bleeding. The stomach being opened, search for the source of blood is often vain. The ulcer may be very small or very inaccessible. A general weeping condition over a large area of gastric mucous membrane may be discovered or villous patches here and there which bleed.

In chronic cases, a white patch on the peritoneal surface of the stomach may be discoverable, a little thickening of stomach wall, a slight induration on palpation, and a sense communicated to the fingers that at this point the several layers of stomach wall are adherent. In other cases a massive tumor may be discovered, composed of adhesions and dense cicatricial infiltration of stomach wall. A differentiation from cancer may be very difficult. The rough, uneven, nodular surface of cancer is wanting. The surface of a massive cicatricial infiltration is white and usually smooth. It is necessary to remember that cancer develops upon the basis of a chronic ulcer in many cases. Upon opening the stomach in cases of chronic ulcer for the control of bleeding, it is often found that the ulcer possesses a hard, densely infiltrated base and borders most unfavorable for the application of ligatures or sutures. The ulcer may have invaded surrounding structures in such a manner that its excision, even, is out of the question. In favorable cases excision of the affected portion of stomach wall may be practiced with success. I excised a large area of stomach wall in a case of chronic ulcer about to perforate, some months ago. The patient has since remained quite well.

Symptoms and Diagnosis of Gastric Ulcer.—Autopsy findings show that gastric ulcer may exist, run its course, and heal without producing recognizable

symptoms. In ordinary cases the only cardinal symptom is bleeding from the stomach, as indicated by vomiting of blood or its passage with the stools—as stated, such bleeding occurs in about one half the cases, and, as will be seen, not even this is always to be relied upon, since bleeding from other sources and under other conditions may cause hematemesis. Thus interference with the portal circulation, whether from cirrhosis, the pressure of tumors, or portal thrombosis, may cause vomiting of blood. Hemorrhage from varicose veins of the gullet or even of the pharynx or from an ulcer at the root of the tongue may exactly simulate that from gastric ulcer. The bleeding from gastric cancer is apt to be continuous, and to appear in daily small quantities in the vomited matters or stomach contents. Vomiting of blood sometimes occurs in cases of hemophilia; mechanical or chemical trauma of the stomach may be followed by hematemesis.

Disturbances of Digestion.—Although an acute ulcer may develop suddenly and produce no symptoms or only be recognized by the occurrence of gastric hemorrhage, its formation is usually followed by symptoms of a definite character. They are vomiting, epigastric pain and tenderness, hyperacidity, and bleeding (hematemesis or melena). If, as happens in many cases, these symptoms are transient and are completely recovered from in a few weeks or months under medical treatment, the condition is in no sense a surgical one, except that operation may be called for in perforation or serious hemorrhage. In chronic cases the patients suffer from pain upon the entrance of food into the stomach. The pain may be merely a sense of burning or oppression in the stomach, or may consist of severe cramplike attacks of epigastric pain. In some cases the pain is nearly constant, is felt independently of the ingestion of food. Tenderness on pressure over the stomach will usually be present, and yet it must be said that similar symptoms occur in gastritis, in cancer, in neurotic affections of the stomach, in ulcer of the duodenum, and in affections of the pancreas, and not infrequently in cholelithiasis and gastroptosis. In addition, loss of appetite, regurgitation of food, pyrosis, usually vomiting, and constipation of the bowels are commonly present. As the result of the pain, the vomiting, the inability to take and digest proper quantities of food, many of these patients suffer severely in general health. They become anemic, weak, and emaciated. A profound degree of neurasthenia often develops, sometimes accompanied by marked hysterical symptoms. Some of these patients acquire the opium habit. In distinguishing chronic from acute ulcer, it is to be borne in mind that the symptoms of the former are often intermittent or remittent. Periods of weeks or months of comparative comfort may intervene, during which the patient improves greatly and suffers but little. It is, therefore, wrong to conclude that the condition is acute without careful inquiry into the previous history.

Motor Insufficiency of the Stomach.—Ulcer of the pylorus is regularly accompanied by obstruction, of a greater or less degree, at the pyloric orifice, due to cicatricial contraction of scar tissue forming the base of a

chronic ulcer; or spasm of the pyloric portion of the stomach the result of irritation, or finally to perigastric adhesions, etc. (See Pyloric Stenosis.) Ulcers situated in other parts of the stomach are quite regularly accompanied by a certain degree of pyloric narrowing of a spasmodic character; in some cases a true muscular hypertrophy and obstruction, usually of only a slight grade. In ulcer a compensatory hypertrophy of muscular wall of the stomach is quite regularly present, so that the symptoms of motor insufficiency are rarely very marked except in cases of cicatricial pyloric stenosis. In cancer, on the other hand, atony of the stomach occurs early in the disease in most cases.

THE GASTRIC JUICE IN ULCER OF THE STOMACH.—*Hyperacidity.*—An increase above the normal content of HCl is the rule in ulcer of the stomach, and taken together with the other signs and symptoms, is of diagnostic value. Such increase may amount to double the normal amount of HCl. It is, however, by no means conclusive evidence of ulcer. The content of HCl may be normal, or, rarely, diminished or absent. When diminished the patients are usually suffering from profound malnutrition and chronic gastritis. It is to be remembered that an excess of HCl does not exclude carcinoma, since cancer, developing on the site of a chronic ulcer, is regularly accompanied in its early stages by hyperacidity, and this may endure throughout the disease. In cases of ulcer complicated by organic pyloric stenosis not only may the percentage of HCl be increased, but also, as mentioned under pyloric stenosis, the amount of gastric secretion may be largely in excess of the normal (gastric succorrhea). This condition obtains in many cases of pyloric stenosis from any cause other than cancer, and in many cases of nervous dyspepsia.

PHYSICAL SIGNS.—*Acute ulcer* produces no physical signs other than, in some cases, localized tenderness. In cases of *chronic ulcer*, deep pressure over the stomach regularly causes pain, and this tenderness on pressure is usually much more marked than in cases of cancer. Chronic ulcer rarely produces a palpable tumor unless marked thickening of the pylorus is present or the individual is very thin. I have, however, noted a distinct sense of resistance in several cases of chronic ulcer of the anterior wall of the stomach not near the pylorus, and have found a dense area of infiltration at operation. In some cases the inflammatory infiltration of the pyloric end of the stomach may reach a palpable size, even in a moderately well-nourished individual; such cases are exceptional, and the existence of such a tumor mass will always arouse the suspicion of cancer rather than of ulcer. When, however, the peritoneal coat of the stomach is penetrated with the production of adhesions to the abdominal wall—a perigastritis, in fact—a palpable mass may be present, but it will usually suggest an inflammatory process rather than a neoplasm. There will be marked tenderness, a more or less diffuse sense of resistance, and often marked rigidity of the overlying rectus muscle. When the abdominal wall itself is invaded the signs of an inflammatory process will be distinct. The surgeon will depend for his diagnosis largely upon a history of severe, and

usually chronic, gastric disturbance antedating the formation of the inflammatory infiltration of the abdominal wall. When marked pyloric stenosis is developed the signs and symptoms of dilated stomach and motor insufficiency will be as described under that condition.

Symptoms of Sudden Perforation into the Peritoneal Cavity.—Perforation of gastric ulcer into the general cavity of the peritoneum is attended by sudden excruciating pain referred to the point of perforation. These patients usually exhibit well-marked symptoms of shock, passing after some hours into those of diffuse purulent peritonitis. The regular picture of the escape of intestinal contents into the peritoneal cavity is developed at once; a rapid, feeble pulse; a pale, pinched, and anxious countenance; hurried, shallow breathing; a retracted, boardlike abdomen, vomiting, abdominal pain, and tenderness, most marked at first over the site of the perforation, to become generalized in a few hours. In the course of five or six hours most of these cases rally somewhat, and the symptoms of shock merge into those of diffuse peritonitis. (See Peritonitis.) The retracted abdomen becomes distended, a febrile movement is developed, together with all the symptoms of intense septic poisoning. Unless operated upon very early, life is terminated within two or three days; rarely such patients may live five or six days. In November, 1908, I was fortunate enough to operate on one of these cases less than four hours after perforation had occurred. The patient, a young woman, had been suddenly seized with a terrific pain in the epigastrium, and had speedily been brought to the hospital. Her history was characteristic, as were the signs and symptoms. A very small cut sufficed to expose the perforation on the anterior wall of the stomach near the pylorus. There was no pyloric stenosis. The perforation was closed by suture. The patient still has hyperacidity, but is otherwise well.

Difficulties in the Diagnosis of Perforated Gastric Ulcer.—In a certain proportion of cases perforation will be the first symptom of gastric ulcer; in others, there will be a history of short or prolonged gastric disturbance of a more or less characteristic kind. In cases belonging to the former group it will not always be possible to distinguish, before opening the abdomen, between perforation of a gastric or duodenal ulcer, perforation of the gall-bladder, a high-placed appendix, and hemorrhagic pancreatitis. Perforation of the vermiform appendix is followed by the same general symptoms and signs as perforation of the stomach, although, as already indicated under Peritonitis, on account of the hyperacidity regularly present, the bacterial content of the stomach and first part of the duodenum is relatively low as compared with that of the ileum and cecum; hence peritoneal sepsis is usually more marked after perforation of the appendix. The symptoms of peritoneal irritation are very marked after perforation of the stomach; the symptoms of sepsis are not so rapidly developed as is the case after perforation of a gangrenous vermiform appendix.

The most important differential signs are the locality of the point of greatest abdominal tenderness and rigidity during the early hours following per-

foration. In perforation of the stomach this will be in the upper part of the abdomen over one or other rectus muscle; in appendicitis it will be over the base of the appendix—i. e., in the right iliac fossa, behind a point about two inches from the anterior superior iliac spine, on a line joining this bony landmark with the umbilicus (McBurney's point). If the surgeon does not see his patient until diffuse peritonitis has become well developed, and in the absence of a proper history of the earlier hours of the disease and of a preceding illness, he will often be unable to make a diagnosis more definite than that of a diffuse purulent peritonitis, probably from the perforation of some hollow organ of the belly.

Practical Suggestions as to the Diagnosis and Treatment of Perforation Peritonitis of Unknown Origin.—The following practical suggestions as to the method of approaching these cases for the purpose of diagnosis and treatment are the result of my own experience in a large number of acute abdominal conditions. When confronted by a case of diffuse peritonitis, or at least by a case presenting evidences of an acute septic intra-abdominal condition, where the history and the general and local signs and symptoms are such that no definite diagnosis can be made as to the origin of the process, where shall the surgeon make his incision in the abdomen? It is generally recommended to cut in the middle line. My own experience would lead me to differ from this view for the following reasons: By far the largest number of septic processes in the belly originate to the right of the middle line or are easily handled through an opening to the right of the middle line of the belly. As already stated, appendicitis is the most frequent cause of perforation peritonitis. Typhoid perforation of the ileum usually occurs quite near the cecum, and is readily found and sutured, using the cecum as a landmark from which to begin a search.

Other common sources of peritoneal infection are perforating ulcer of the duodenum and pyloric portion of the stomach; septic processes of the gall-bladder and the biliary ducts. All these lesions are readily reached and treated through a cut through the outer third of the right rectus muscle. Some of them cannot be handled through a median incision unless it is very large. Accordingly, when unable to locate the origin of the infection, I make a vertical incision about two inches in length through the outer third of the right rectus muscle, the center of which is about opposite the umbilicus. Through this cut it is usually possible, from palpation and inspection, quickly to find the infecting lesion. The intensity of the inflammation of peritoneum, the direction from which the thickest pus in largest amount is seen to flow, the quantity of fibrin on the coils of gut, the presence or absence of odor in the exudate, and the presence of bile often serve as guides to the original lesion. With good retraction and the proper use of pads the belly can be thoroughly explored, and various organs brought into the field of vision without much difficulty; and from this wound the different organs may be palpated in a satisfactory manner. If the lesion is found to be in the stomach, duodenum, or gall-bladder,

the incision may be enlarged upward to a sufficient extent. If the appendix is at fault, it may be readily removed though this cut.

If, as will very rarely happen, a previous examination *per vaginam* having been made in the case of a female, an unsuspected lesion of the uterine appendages is discovered, a moderate enlargement of the incision downward gives fairly good access to them. As a matter of practical experience, I have found it very rarely necessary to make a second cut in some other part of the abdomen.

In private practice the instances in which no previous history of a case is obtainable, and no intelligent observation has been made of the earlier hours of an acute illness, will be exceedingly infrequent. In the hospitals of the city of New York many cases are admitted concerning whom little or no reliable information of any kind is obtainable. Partly on account of the ignorance of the patients and their friends; partly because they are Slavs, or Syrians, or Russian Jews, or belong to some other race with whom it is impossible to converse.

Localized Peritonitis from Perforated Gastric Ulcer.—In those cases of perforation from gastric ulcer where adhesions, though formed, are inadequate, there will result a localized peritonitis with abscess. The signs and symptoms will be those of acute or subacute sepsis, together with symptoms of disturbance of the stomach and the formation of a localized intraperitoneal inflammatory exudate. (See Localized Peritonitis and Subphrenic Abscess.) Such an abscess may perforate in various directions, as already indicated, and eventuate in a general infection of the peritoneum, an external or internal gastric fistula, subphrenic abscess, empyema, pericarditis, etc.

Differential Diagnosis and Operative Indications in Ulcer of the Stomach, Neurotic Dyspepsia, and General Enteroptosis.—While many cases of gastric ulcer fall into a state of neurasthenia, it is to be remembered that neurotic dyspepsia may closely simulate ulcer of the stomach, hyperacidity being common in the former condition, bleeding being absent, as well as evidences of dilated stomach or other sign of pyloric obstruction. Such patients are hardly likely to be benefited by any operation on the stomach; they are more likely to be made worse. General enteroptosis is usually accompanied by neurasthenia. The stomach takes part in the general sagging of the viscera, and may show evidences of moderate dilatation. The kidneys are often movable; the liver often descends below the free border of the ribs a considerable distance. Such patients are usually women; they frequently suffer from uterine displacements and from gastric dyspepsia. Generally speaking, they are not materially benefited by fixation of their various movable organs. The neurasthenic state remains, and unless the stomach shows well-marked evidences of motor insufficiency, stagnation of food, marked fermentative changes, etc., they are not proper subjects for gastro-enterostomy. These unfortunates belong to the class who acquire the surgical-operation habit, and who go about having first one organ and then another operated upon by overenthusiastic surgeons, usually

without permanent relief; on the contrary, their neurasthenic condition is commonly rendered inveterate. Gall-stone disease, when accompanied by a localized adhesive peritonitis, and matting together of the pylorus, duodenum, and gall-bladder, may, in the absence of jaundice, closely simulate ulcer of the stomach. The absence of hemorrhage and the presence of a palpable, tender gall-bladder, together with a history of acute intermittent attacks of pain, will generally enable the surgeon to differentiate the conditions, though not always. Symptoms of pyloric stenosis may be caused by such adhesions—i. e., gastric pain and motor insufficiency, and a dilated stomach. The ulceration of a large gall-stone impacted in the cystic duct into the duodenum or stomach may suggest ulcer of the duodenum or stomach. In these an operation will be the only means whereby a certain diagnosis is possible.

Epigastric Hernia.—As already noted, the small herniæ found in the linea alba between the ensiform cartilage and the umbilicus sometimes causes severe gastric pain and digestive disturbances. They should be sought for in cases exhibiting such symptoms.

Ulcer of the Duodenum.—The symptoms of ulcer of the duodenum may so closely resemble those of gastric ulcer that no differential diagnosis is possible. (See Ulcer of the Duodenum.)

Cancer.—As noted, chronic ulcer of the stomach eventuates in cancer in not a few instances. The new growth may develop in the scar of a healed ulcer, or upon the raw surface of the ulcer itself. The presence of a distinct tumor renders the diagnosis of cancer more probable than that of ulcer.

Operative Indications in Ulcer of the Stomach.—The following conditions justify operative interference in ulcer of the stomach: Perforation with diffuse peritonitis or the formation of a localized abscess. Perforation and inflammatory infiltration of the abdominal wall. The immediate indications in these cases are cleansing and drainage and closure of the perforation if possible. Pyloric stenosis, giving the evidences of marked motor insufficiency and dilated stomach. Severe pain and serious disturbances of the general health. Posterior gastro-enterostomy by suture with a short jejunal loop gives the best results. Hour-glass stomach. Separation of adhesions and a plastic operation upon the stomach, if that be possible, for the relief of deformity. Failing this, posterior gastro-enterostomy. In repeated hemorrhages causing marked anemia, gastro-enterostomy promises the best results. Sudden severe bleeding threatening death from acute anemia justifies opening the stomach to search for and control the bleeding and, if conditions permit, gastro-enterostomy. Unfortunately, in these cases the technical difficulties are often insurmountable, as already pointed out. The source of bleeding is a large vessel, more often in the pancreas than elsewhere, sometimes the coronary artery (von Mikulicz's case), the splenic, or other large vessel; and frequently so placed as to be inaccessible and surrounded by tissues of a character most unfavorable for the application of sutures or ligatures. A few cases only of this class have been operated successfully.

B. F. Curtis succeeded in stopping a severe hemorrhage of this kind by including a neighboring vessel of some size in a ligature. The vessel was visible beneath the peritoneal coat of the stomach. In place of gastro-enterostomy Rodman advocated excision of the ulcer-bearing area of the stomach—pylorectomy, in fact. The number of cases so treated is not yet sufficiently great to establish that the method possesses material advantages over gastro-enterostomy. When marked pyloric stenosis exists and much inflammatory thickening of the ulcerated pylorus, the prevention of cancer can best be accomplished by pylorectomy.

The above discussion of the surgical aspects of ulcer of the stomach is by no means intended to convey the idea that all cases demand surgical treatment. We are informed by medical men of long experience and great practical wisdom that many patients the subjects of gastric ulcer are permanently cured by medical means. The surgery of the stomach has advanced in safety and efficiency within the last eight years (1908) in a remarkable manner. I believe, however, that the surgeon will do well to select his cases for operation with care and discrimination, choosing those for operation only where the indications are positive, or where medical treatment has failed to relieve a condition which seriously impairs the usefulness of the individual. Crämer, who has studied this subject very carefully, says that any dilatation not vastly improved after four weeks of gastric lavage, suitable diet and massage, should be considered a proper case for operation.

PERFORATING ULCER OF THE DUODENUM

Perforating ulcer of the duodenum has been regarded until within the past few years as a rare disease. More careful observation and more numerous operations would, at present, seem to indicate that the disease is much more common than was formerly believed. A good many cases are associated with gastric ulcer. It is probably as common as ulcer of the stomach, and perforations are believed to be quite frequent. Thus Moynihan in twenty-two cases of acute perforating ulcer found fifteen in the stomach, seven in the duodenum. The Mayo brothers, in twenty-seven cases of perforation, found eleven in the stomach, sixteen in the duodenum. Brunner collected six hundred cases of acute perforation, of which twenty-five per cent were duodenum. In my own experience in the New York and Roosevelt hospitals the number of gastric perforations has been about double the number of those in the duodenum. Aside from duodenal ulcers following extensive burns of the integument and the very rare cases after abdominal operations, the causes of which are not entirely clear, but are thought to be due to a localized thrombosis of the intestinal vessels, ulcer of the duodenum appears to be due to the same causes as gastric ulcer—namely, to a digestion of the intestinal wall by the acid gastric juice. The anatomical characters are the same as in gastric ulcer. The ulcers following burns and abdominal operations are often multiple, and frequently

perforate with a fatal result in a few days, or within a fortnight after the occurrence of the injury. The ordinary peptic ulcers are usually single and more often run a chronic course. They vary in size and shape from minute rounded points to irregular ulcerated areas completely surrounding the gut.

By far the largest number of ulcers occur in the first horizontal and second descending portions of the duodenum; sometimes just at the junction with the pylorus, not infrequently as low as the orifice of the common duct, never below that point. Unlike gastric ulcer, ulcer of the duodenum is much more frequent in men than in women. Statistics would seem to place the relative frequency in the two sexes at about four to one. While no age is exempt, ulcers having been observed in young infants and in old people, the largest number occur during the fourth decade of life. The situation of the ulcer is more often on the anterior than on the posterior wall of the duodenum; hence perforation leads more often to infection of the peritoneal cavity than to perforation into neighboring organs or retroperitoneal abscess or phlegmon. It is estimated that about half the cases of duodenal ulcer perforate. In the chronic cases slow perforation is very common, with the production of a periduodenitis and abundant adhesions binding the intestine to the surrounding structures, notably to the gall-bladder and to the cystic duct.

Symptoms and Signs of Duodenal Ulcer.—Although the symptoms of ulcer of the duodenum are similar to those of ulcer of the stomach, there are certain distinguishing characters. As in gastric ulcer, hyperacidity is the rule. The digestive disturbances are less marked, or if pain and distress after eating are marked symptoms, they are apt not to be felt immediately after swallowing food, as in gastric ulcer, but to be delayed for some little time. Palpation elicits tenderness over the seat of the ulcer. The seat of pain and tenderness is distinctly farther to the right than in gastric ulcer. In a case of my own, described below, there was a point of extreme tenderness three inches above the umbilicus and an inch and a half to the right of the median line. The existence of ulcer is far more apt to be unsuspected than is the case with gastric ulcer. Symptoms of disturbances of gastric digestion may be entirely wanting, there may be no vomiting; the general health may be in no way interfered with until the occurrence of a dangerous complication, perforation or hemorrhage.

Complications.—Jaundice may exist as a complication owing to involvement of the common duct in a cicatrical mass or simply to a complicating catarrhal inflammation of the duodenum; as a result of periduodenitis and adhesions to gall-bladder and cystic duct. The symptoms may clearly simulate cholecystitis from gall-stone disease. Pyloric spasm and gastric dilatation are much less frequent than in gastric ulcer. Stenosis of the duodenum as the result of cicatricial contraction is an occasional result, and produces special symptoms, according to its location, to be described later. Hemorrhage of a dangerous or fatal character is a very common event, due to perforation of any of the large neighboring vascular trunks—the gastro-epiploic, the gastro-

duodenal, the hepatic arteries or the aorta, the portal vein or the vena cava. Such hemorrhage is usually fatal; the blood may be vomited or passed *per rectum*, or both. The occurrence of vomiting without blood in the vomited matters and of marked melena suggests the duodenum as a source of bleeding, although some lower part of the gut cannot, of course, be excluded. Small and repeated hemorrhages are far less common than in ulcer of the stomach; they occasionally occur, and may lead to profound chronic anemia.

Perforation.—Perforation into the free cavity of the peritoneum results in peritoneal sepsis or diffuse purulent peritonitis. Perforation so commonly takes place without warning in a patient previously in good health that the diagnosis is often missed. Appendicitis is the most common diagnosis made in these cases, or perforation of the stomach, or acute suppurative inflammation of the gall-bladder; sometimes acute obstruction of the bowels, if the case is not seen for a number of hours and the peritonitis is far advanced. The reason for the frequent diagnosis of appendicitis is that the lesion is, in its early stages, quite evidently situated on the right side of the belly, and is attended by early symptoms quite in accord with the history of a sudden perforation of the appendix. The location of the initial pain and subsequent localized tenderness and muscular rigidity are suggestive of the correct position of the lesion during the early hours after the perforation. (In some cases the pain may be a general abdominal pain, subsequently localized near the umbilicus (Blake's case)). The distinguishing location of pain and tenderness is often lost after the peritoneal inflammation has become more diffuse; for the following reasons: The natural course for the spread of peritonitis originating in the duodenum is along the surface of the hepatic flexure down the ascending colon to the right iliac fossa, thence, as in appendicitis, to the bottom of the pelvis, thence upward along the rectum and sigmoid to the left flank. Hence quite early in the progress of the case there will be found pain, tenderness, and muscular rigidity in the right iliac fossa.

The following case history I insert in full, since it is quite characteristic, sufficiently so for a positive diagnosis had I weighed the signs and symptoms more carefully:

Case of Perforating Ulcer of the Duodenum.—A man, aged twenty-seven years, was admitted to Roosevelt Hospital at 3 A.M., March 28, 1899, with the history that four days before admission, having been up to that time in good health and free from digestive disturbances, he was seized with colicky pains, referred to a point above the navel and to the right of the median line. There was no vomiting and he did not have a chill. His pains were not severe, but they continued during the following two days, and were always referred to the same region. His bowels moved daily, and he remained at his work. At 1.30 A.M. of the day of his admission he was awakened by severe abdominal pains, which were most intense three inches above the navel and a little to the right of the median line. They were followed by a chill, which lasted half an hour. There was no nausea, but the patient took a dose of mustard and

water, which induced free vomiting, the vomited matter consisting of partly digested food and the mustard and water which had just been taken; no other ingredients were noted. He felt feverish, and the pain was so intense that he sent for an ambulance and was brought to the hospital, arriving at 3 A.M.

When admitted his abdomen was not distended, but was moderately tender, with well-marked muscular rigidity throughout. The tenderness was most marked over an area about two inches in diameter, located three inches above the navel, and with its center an inch and a half to the right.

A small dose of morphin was then given hypodermically for the relief of his pain. At 10 A.M. his pain was somewhat less severe, the tenderness more marked and localized, as before. There was general rigidity of the abdominal wall. His temperature had risen to 101.5° F.; pulse, 80; respirations, 20. The diagnosis was made of an acute intra-abdominal inflammation, probably of a suppurative character, upon the right side of the abdomen, its exact anatomical situation being unknown. At 11.30 A.M. the abdomen was opened by an incision, two inches and a half long, in the right semilunar line, with its center at the level of the umbilicus. Upon opening the cavity of the belly a considerable quantity of cloudy, bile-stained fluid, containing flakes of fibrin, escaped. The probable diagnosis of perforated ulcer of the duodenum was then made; as a matter of precaution, however, the vermiform appendix was sought for, and was found to be normal. The incision was extended vertically upward to the free border of the ribs. The large and small intestines, the gall-bladder, the under surface of the liver, and the anterior wall of the stomach showed evidences of acute irritation, and were coated here and there with patches of grayish fibrin. Upon the anterior surface of the descending portion of the duodenum, a little to the right and about midway between the junction of the second and third portions, above the point where the second part passes behind the transverse mesocolon, was seen a rounded or oval perforation, large enough to admit a No. 26 French sound, or thereabouts, through which was escaping bile mixed with other intestinal contents. The border of the ulcer was clean-cut, not ragged. A pad of gauze was held over the ulcer, and the neighboring portion of the abdomen was thoroughly washed with salt and water. The opening of the duodenum was encircled with a purse-string suture of catgut, the edges of the ulcer were inverted into the intestine, and the suture was tied. The closure was further strengthened, and the tension upon the purse string relieved by four Lembert stitches of catgut, introduced along a line parallel with the axis of the gut. The remainder of the greater peritoneal cavity was then examined. A considerable quantity of bile-stained, cloudy fluid was found at the bottom of the pelvis, and the intestines were everywhere moderately reddened and coated with disseminated patches of fibrin. The edges of the wound were held wide apart, and the entire abdomen was repeatedly flushed out with hot water and salt, without evisceration, the fluid being gently stirred about with the hand in the abdomen. The entire cavity was wiped dry with large pads of sterile gauze. A strand of gauze packing was then

introduced down to the site of the ulcer and brought out at the upper angle of the wound. The remainder of the wound was then closed with sutures. The patient did not suffer from shock. He was fed *per rectum* for forty-eight hours. His temperature, on the day following the operation, rose to 101° F., after which the elevations of temperature were trifling. The superficial wound was dressed on the third day, and appeared to be slightly infected. The skin sutures were thereupon removed. The deep packing was removed on the fourth day, and was found to be clean. Excepting the superficial infection of the skin wound, which necessitated the prolonged use of adhesive straps in order to encourage union of the skin edges, the patient's convalescence was uninterrupted. He remained in bed four weeks after the operation, and six weeks after the operation he appeared to be in the best of health.

This man was kept under observation for a year; he remained in good health and developed no symptoms of duodenal stenosis.

Untreated surgically, the peritonitis ends fatally in most instances. In a few cases (two such have come under my observation) a localized abscess is formed between the duodenum and the liver. Right-sided subphrenic abscess is a common complication of these cases. If the perforation takes place on the posterior retroperitoneal surface of the duodenum, erosion and opening of a large blood-vessel, as already described, may occur; in other cases a retroperitoneal phlegmonous inflammation with fatal results. In both localized abscess and retroperitoneal phlegmon gas is apt to be present in the exudate. In a certain proportion of duodenal ulcers without either perforation or serious bleeding there are associated severe pain and marked disturbances of digestion, these are the cases in which obstruction of the duodenum, as the result of cicatricial contraction, occurs. (See Intestinal Obstruction.) The cases of chronic ulceration and slow perforation with the formation of extensive adhesions to gall-bladder, liver, cystic duct, and gastrohepatic omentum will usually be diagnosticated as affections of the biliary passages. The cases associated with marked gastric disturbances, often with ulcer of the stomach, will be regarded as cases of gastric ulcer.

The surgical indications in the cases where operation is not done for perforation or hemorrhage are: (1) Rest for the duodenum and the relief of obstructive symptoms, if such exist; these are best accomplished by posterior gastro-enterostomy. (2) Separation of adhesions which may be interfering with the function of the biliary passages or the pylorus or duodenum. (3) Excision of the ulcer, if suitably placed, or if perforation is threatening. The position of the ulcer in chronic cases may often be detected by a white spot on the surface of the gut or an area of palpable infiltration.

From the foregoing, it will be seen that ulcer of the duodenum is a very dangerous and often fatal disease. The fact that an ulcer may exist for a long time and give no symptoms, suddenly to perforate or bleed the patient to death makes the outcome appear like a fatal bolt of lightning out of a clear sky, and renders the exact diagnosis exceedingly difficult. It nearly always

happens when perforation occurs that no exact diagnosis is made until after opening the belly, and in many instances the condition has been so desperate that the cause of the peritonitis has not been found until after death.

ACUTE SUPPURATIVE GASTRITIS: ABSCESS OF THE STOMACH. PHLEGMONOUS INFLAMMATION OF THE STOMACH

Acute purulent inflammation of the wall of the stomach, originating not in the mucous membrane, nor in the peritoneum, but in the submucous fibrous layer of connective tissue, may occur as a localized process (abscess of the stomach) or as a diffuse purulent infiltration (phlegmonous gastritis). Fortunately a rare disease, since only a very few of the recorded cases have survived (among them one is recorded by von Mikulicz, one by Lengemann).

Diffuse Phlegmon of the Stomach

The causation of the condition is sometimes entirely obscure; in other cases the lesion of the stomach occurs as a metastatic hematogenous process in the course of pyemia or septicopyemia, in some cases as a complication of puerperal sepsis. In a certain number of instances an ulcerated carcinoma was present in the stomach; much more rarely a simple peptic ulcer. Some cases have followed trauma, either subcutaneous injuries, accidental open wounds, or surgical operations upon the stomach; in a few cases ulceration of the stomach wall from the pressure of foreign bodies, occasionally the swallowing of caustic liquids. The phlegmonous variety has been observed in the course of anthrax. The abscess or phlegmon is commonly situated near the pyloric end of the stomach. Perforation may take place through the mucous membrane into the cavity of the stomach or into the peritoneal cavity, or both.

The symptoms are those of an intense, acute sepsis, associated with those of an acute inflammatory process of the stomach. The course of the disease is usually short, death occurring in a few days. The patient is seized with severe pain in the stomach, repeated uncontrollable vomiting, extreme tenderness, and rigidity of the upper part of the abdomen. The constitutional symptoms are severe and progressive until death. There is usually a marked rise of temperature, great prostration, and a progressively rapid and feeble pulse. The diagnosis in the most acute cases is apt to be that of perforation of gastric ulcer and diffuse peritonitis. In those not quite so acute, the diagnosis of a localized abscess from slow perforation of gastric ulcer will be made; the infiltrated wall of the stomach may feel like a circumscribed peritoneal exudate on palpation. Early operative drainage gives the only possible hope of recovery.

GASTRIC TETANY

In certain rare cases of injuries and diseases of the stomach there occur convulsive seizures of a peculiar kind, sometimes accompanied by loss of con-

sciousness. The picture bears a certain resemblance to tetanus, on the one hand, and to epilepsy on the other. The disease has been fatal in a large proportion of cases treated by medical means. Operation in suitable cases has been followed by recovery (stomach drainage by gastro-enterostomy). A number of theories have been advanced to account for the condition; probably it is a toxemia caused by the absorption from the stomach of poisonous decomposition products developed in the stomach contents. (See also Tetany after Removal of the Thyroid Gland.) In nearly all the observed cases there has been motor insufficiency, a dilated stomach, and stagnation of gastric contents due to pyloric or duodenal stenosis from one cause or another; rarely has this factor been absent. Hyperacidity is commonly present. The attack may occur spontaneously in the course of chronic disease of the stomach or may follow a surgical operation or an injury to the organ, or, as in one case (Warbasse), the retention in the stomach of a large number of foreign bodies. An unusual case was observed by Hermann Fischer, following seventeen days after an operation for fibro-lipoma of the stomach. The patient recovered. It is probable that mild grades of tetany are not uncommon in cases of dilated stomach with retention and fermentation of stomach contents. Crämer has called attention to these cases; the symptoms are muscular twitching and paresthesia; he considers these signs an indication for surgical interference in cases of dilated stomach.

The convulsive seizures often follow the effort of the distended stomach to empty itself by vomiting; sometimes the passage of a stomach-tube; occasionally an attack may be induced by tapping the abdomen over the stomach. The convulsions consist in typical cases of tetanic spasms and fibrillary twitchings of certain groups of muscles. Usually the muscles of the forearm are first affected. The position assumed by the hand is characteristic. The metacarpophalangeal joints are flexed, the phalanges are extended, the thumb is adducted into the palm, the so-called "obstetrical hand." The wrist and elbow are often strongly flexed. The contractions may be confined to the muscles of the upper extremity or may spread to the muscles of the abdomen, back, and legs. The condition of opisthotonos is sometimes present. Usually the patient loses consciousness. The spasms may last a number of minutes or half an hour, and gradually subside, to be renewed at irregular intervals.

Isolated spasms may be produced by mild electrical stimulation of the muscles, by pressure on the blood-vessels and nerves of the arm (Trousseau's phenomenon), kept up for a minute or more. Tapping the cheek in front of the lobule of the ear over the facial nerve causes spasmodic contraction of the orbicularis oris muscle on that side and elevation of the corner of the mouth, sometimes spasm of the entire side of the face (Chvostek's symptom). In bad cases the muscular spasms are widespread, the duration of the tetanic contractions is considerable. The diaphragm may be involved and threaten death from respiratory failure. The attacks are frequently repeated, and continue to become more severe until death. In milder cases removal of the obstruction,

or the mass of foreign bodies, as the case may be, or gastric lavage causes improvement and final cure.

An unusual case was reported by Gatzsky, following a subcutaneous injury to the upper part of the abdomen by blunt violence. The patient had severe pain in the stomach, frequent vomiting, tenderness and rigidity of the abdominal wall. Tetany began four weeks after the injury, and was speedily fatal in spite of gastric lavage. At the autopsy enormous acute dilatation of the stomach was found, caused by total obstruction of the descending portion of the duodenum due to the pressure of a large retroperitoneal hematoma. In Warbasse's case the individual was a professional swallower of foreign bodies, who was twice operated upon for the removal of accumulations of metal objects —nails, knives, spoons, chains, etc.—from his stomach. For a period of several years he had suffered from occasional tetanic seizures with loss of consciousness, the nature of which had not been recognized. There was no pyloric obstruction. The stomach was nearly normal in size and appearance, although the weight of metal objects had caused a slight pouch along the greater curvature. Upon emptying the stomach the attacks ceased.

Warbasse says: "Sometimes during the intervals between attacks the patient regained consciousness, and entered into conversation, at other times the spasms followed in quick succession. These seizures presented three stages: (1) All of the attacks were preceded by vomiting or a violent effort at vomiting. (2) This was always followed by a sensation of choking, as though he were being strangled and could not get air, evidently a spasm of the glottis muscles. (3) He then fell unconscious to the floor, and the convulsions immediately supervened. During the first two stages there was always a sensation of dizziness. After from one to six or eight convulsions the attack subsided, and the patient went about his business."

Warbasse considers that this case favors the theory of the mechanical causation of gastric tetany. It has been observed in a good many cases of dilated stomach with stagnation of stomach contents that the introduction of a stomach-tube and washing of the stomach has been followed by an attack of tetany. It is believed that dilution of the stomach contents may have rendered the poisonous ingredients more readily absorbable. It is therefore wise in these cases to remove as far as possible the contents of the stomach by aspiration and siphonage before introducing water into the stomach.

TUMORS OF THE STOMACH

Cancer of the Stomach.—From time to time benign tumors are observed in the stomach as surgical rarities, sometimes producing symptoms, more often not. Carcinoma, on the other hand, is exceedingly common, and here, as elsewhere, carries the patient to his grave with absolute certainty. The duration of life in cancer of the stomach is very short; after the disease is so far developed that the diagnosis is plain, the average duration of life is only one year.

At the present time no topic is of greater interest to surgeons than the operative treatment of diseases of the stomach. The labors of Billroth, Czerny, Wölfler, Krönlein, Maydl, von Hacker, Hartmann, Cuneo, Moynihan, Mayo Robson, the Mayos, and others have so far developed the surgery of the stomach as to demonstrate that in cases of cancer, early, thorough operative removal is not attended by an unduly high mortality, presents no insurmountable technical difficulties, prolongs life in many cases, and cures permanently a certain number of unfortunates otherwise doomed.

Murphy collected 189 cases of operation; of these, 17, or eight per cent, lived three years. The general mortality from the operation was fifteen per cent. There were, however, a few recurrences after this period. A certain number are doubtless permanently cured. The statistics of von Mikulicz's clinic were as follows:

Of 58 cases who survived the operation, 20 lived from six months to eight and a quarter years; of these, 17 more than a year, 10 more than two years, 4 more than three and a half years; the last 4 still remained alive and well, and might, therefore, be regarded as permanently cured.

W. J. Mayo's statistics, October, 1905, are as follows:

Report of 81 gastric resections, with mortality of 14.5 per cent, including early operations: 34 patients operated upon in the last thirty months with a mortality of 8 per cent; 25 consecutive with 1 death, 4 per cent. As to relief, 11 operated upon too recently to be of value as to cure; 5 failed to live six months; 38 lived six months to a year, and 24 are alive now; 21 from one to two years, and 13 alive; 10 from two to three years, and 8 alive; 4 from three to four years, and 3 alive; as only 16 were operated upon more than three years ago, this gives 25 per cent living three years. One is alive and well after four years and ten months.

In discussing the symptoms and diagnosis of cancer of the stomach it is to be borne in mind that most advanced cases present unmistakable symptoms, such that the diagnosis is entirely simple, but that when this stage is reached the disease has spread beyond the power of surgery to eradicate it, palliation is alone possible. The early diagnosis of cancer of the stomach thus becomes a problem of the greatest importance. Unfortunately, there are no clinical signs and symptoms enabling us to make a certain diagnosis at a very early period of the disease. The general statement was formerly made, and believed by many, that when a palpable tumor was present the disease was already too far advanced for radical operative relief; further experience has, however, shown that this view, while generally true, is not always so. As has been pointed out by W. J. Mayo and others, a small movable pyloric tumor may be a rather favorable sign than otherwise, and by no means indicates a hopeless condition. Nor is the absence of a palpable tumor a favorable sign. The most hopeless cases are the cancers of the body, posterior wall, and cardiac portion of the stomach; lying, as they do, deeply placed behind the ribs, they may

go on to a fatal issue, and even grow to a large size without at any time becoming palpable.

The dictum of modern surgery is that cases of stomach disturbance presenting symptoms leading to a suspicion of cancer should be told the exact state of our knowledge on the subject. The dangers of delay should be dwelt upon and the individual given the opportunity of an accurate diagnosis, only obtainable by an exploratory incision. The risks of the procedure are small, the information thus obtained is definite and furnishes the surgeon with a certain guide to the radical or palliative treatment of the case. Should the condition be found inoperable, the patient will have suffered but little additional pain and discomfort, and need be confined to bed only a few days. Indeed, with proper methods of suturing, the sooner he is out of bed the better, since these individuals rapidly lose strength when kept recumbent, and are apt to develop hypostatic pneumonia. With these preliminary remarks we may proceed to discuss the characters of the disease.

Causation.—We know as little of the causes of cancer of the stomach as of other cancers—namely, very little. The disease occurs not infrequently upon an open chronic ulcer of the stomach or upon a scar where an ulcer formerly existed. As is true of all cancers, trauma, and especially long-continued mechanical irritation, appear to be to some extent determining factors in the location of the disease. The narrower portions of the stomach being exposed to more mechanical insults are the seats of predilection—i. e., the pyloric portion of the lesser curvature, the pylorus, less often the cardia. Sudden direct trauma is probably a very rare cause, indeed. In a certain proportion of cases there will have been a history of injury to the abdomen preceding the symptoms of cancer, in many of these the growth was no doubt present at the time the injury was received, and has grown the faster as the result of such an injury. In others the new growth appears, no doubt, quite independently, but is referred by the patient to some insignificant injury remembered to have occurred at perhaps an unduly remote date.

Occurrence.—Cancer of the stomach is the most frequent seat of human cancer. The percentage of its occurrence varies in different statistics: Welch gives it as 21.4 per cent of all cancers; Virchow, 35 per cent; others, as high as 40 per cent. The disease affects men and women equally. It is, in general, a disease of advanced life; two thirds of the cases occurring between the ages of forty and sixty years. It does, nevertheless, occur at earlier ages; in the third and fourth decades, and even earlier. I operated on a boy, aged fifteen years, for an undoubted carcinoma of the stomach. The most frequent starting points are the pylorus and the lesser curvature close to the pylorus; the latter situation being probably the more frequent of the two. About three fourths of the cancers start in one of these two places. About ten per cent begin in the cardia; the remainder are distributed throughout the rest of the stomach.

Varieties.—Several varieties of cancer occur in the stomach, although of no great moment from a diagnostic point of view. They may be here men-

tioned. Borrmann's classification: (1) Carcinoma simplex—carcinoma solidum (Borrmann). Cells in strings and irregular masses, with a variable amount of connective-tissue stroma, and a corresponding variability in rapidity of growth. (2) Colloid cancer—originating as such, or a degeneration form from Number 1; of slow, sometimes of rapid growth. (3) Diffuse polymorphous-celled cancer (Borrmann). An infiltrating cancer without microscopic boundaries, spreading especially in the subserous tissue. (4) Cylinder-celled cancer, of slow growth. A tubular cancer. Tubules lined with one or more layers of cylindrical epithelium. (5) Glandular cancer, adenoma malignum. (6) Mixed forms. Any of these, with the exception of the diffuse infiltrating form, may assume the type of scirrhous carcinoma.

Macroscopically, we may distinguish circumscribed sharply bounded tumors of the stomach wall and those which show a tendency to infiltration more or less insidious and widespread; a very large part of the stomach may thus be involved in the growth. The stomach may be greatly thickened and its cavity much diminished in size. The mode of growth of cancer of the stomach is important from the surgical point of view. The spread of the disease follows the course of the lymphatic circulation of the stomach. In this connection it is to be borne in mind that, *as a rule, only those tumors originating in and confined to the pylorus and adjacent portion of lesser curvature are amenable to operative removal.*

Lymphatics of the Stomach.—The course of lymphatics of the stomach was carefully worked out by Cuneo and Most. The following are some of the important data as given by them:

The general lymphatic circulation of the stomach empties into a series of lymphatic glands grouped about the celiac axis, "celiac lymph glands," lying behind the stomach along the upper border of the pancreas, extending to the right behind the pylorus and to the left as far as the spleen. Before arriving at these glands the lymphatics of the stomach pass through a number of smaller glands grouped along the lesser and greater curvatures and about the cardia. According to the arrangement of the lymph channels in reference to these glands, the stomach may be divided into three lymphatic territories, including both anterior and posterior walls of the stomach:

(1) The largest of these territories drains itself into lymph glands situated along the lesser curvature and near the cardiac—"the superior gastric lymph glands." These glands receive the lymph from the largest portion of both anterior and posterior walls of the stomach. (2) A few lymph channels and lymph glands are to be found along the right half of the greater curvature and at the pylorus. The lymph current is from left to right. They accompany the gastro-epiploic artery and are more numerous in the vicinity of the pylorus. These are known as "inferior gastric lymph glands." They empty into lymph channels passing to the celiac glands. (3) The smallest territory, comprising the left or fundus half of the greater curvature, empties into glands lying in the hilus of the spleen. A few of these channels pass direct into the celiac glands along the border of the pancreas.

Lymphatic involvement occurs very early in cancer of the stomach, and the possibility of cure depends upon the radical removal of all infected structures. The following practical deductions derived from pathological study and operative results have been developed by von Mikulicz, Hartmann, Moynihan, Robson, W. J. Mayo, and others. Cancer of the lesser curvature requires the removal of the entire lesser curvature and its associated lymphatics as far as the gastric artery, including the lesser omentum (von Mikulicz). The glands along the right half of the greater curvature are also to be removed, although not always infected. In cancer of the pylorus both of these groups are infected at an early date. When the celiac glands are also infected, their removal, owing to their position, is always difficult, frequently impossible. The fact that glands are enlarged does not necessarily indicate that they are carcinomatous. Enlarged glands occur both in ulcer and ulcerating carcinomata from inflammatory hyperplasia merely. The presence of a large tumor does not necessarily indicate extensive lymphatic infection.

Owing to the arrangement of lymphatic drainage in the stomach, it is often possible to preserve the fundus and a large part of the greater curvature without risk. The actual point of section depends upon the extent of disease; it should be well to the left of the group of pyloric glands on the greater curvature. The celiac glands once passed, the glands lying in front of the great vessels as they pass through the diaphragm are involved, the disease soon reaches the thoracic duct and so the general blood current at the junction of the left internal jugular and subclavian veins. Involvement of the supraclavicular lymph nodes occurs at a period of the disease when it has ceased to possess a surgical interest.

Hematogenous Infection.—In addition to lymphatic infection, hematogenous infection through the gastric and other veins occurs during the later stages of the disease, or even sometimes quite early. In this manner a rapidly growing metastatic carcinoma of the liver may exist as a large tumor or tumors, even before the cancer of the stomach has become palpable, or has produced marked gastric disturbances. By direct extension cancer of the stomach invades the surrounding organs, the transverse colon, the abdominal wall, the duodenum, bile passages, and liver. Infection of the peritoneum with cancer cells occurs when the peritoneal coat of the stomach is penetrated. These secondary carcinomata of the peritoneum appear as numerous, minute, white or pinkish nodules scattered over the serous covering of the stomach, the surrounding viscera and the abdominal wall. At first they are the size of the head of a pin; later they may, if the patient survives, grow into considerable tumor masses. The condition is associated with an accumulation of clear or blood-stained fluid in the abdomen (cancerous peritonitis). Sooner or later every cancer of the stomach is acted upon by the gastric juice, breaks down on its surface, and undergoes destructive ulceration. According to the character and shape of the tumor, cavities in the tumor mass are thus created, or broad, undermined, or fungating cancerous ulcers.

Penetration of the abdominal wall may produce secondary tumor masses in the skin and subcutaneous tissues. Rarely, ulceration and perforation takes place with the formation of a gastric fistula. Perforation of an ulcerated carcinoma into the cavity of the peritoneum causes purulent peritonitis. Other complications may occur—septic thrombosis of the portal vein, hemorrhage from the erosion of vessels, etc. The wall of the stomach not occupied by the cancer early undergoes important changes; among them, a catarrhal gastritis is soon developed and general atony of the entire stomach wall. The character of the gastric secretion is changed. There is usually diminution or absence of HCl. Motor insufficiency; fermentative changes, the formation of lactic acid, bacterial multiplication, etc.

Symptoms, Course of the Disease, and Diagnosis of Gastric Cancer.—The symptoms of cancer of the stomach vary a good deal in different cases, according to the situation of the tumor in the stomach. A growth occupying the pylorus or cardia will usually cause pyloric stenosis or symptoms resembling obstruction of the lower end of the esophagus, respectively, although in cancer of the cardia obstructive symptoms may be long delayed or even absent. That is to say, when the cancer obstructs the pylorus or cardia, in addition to rapidly progressive digestive disturbances—vomiting of food, pain, and other symptoms to be spoken of later in detail—the patient will rapidly emaciate from actual starvation. The loss of body fluids will be especially noticeable. There will be a gradual drying up of the entire organism. The panniculus adiposus will disappear, the skin may be picked up readily in folds. The amount of urine will be small. The watery constituents of the blood will be diminished. The content of hemoglobin in such dehydrated blood may long remain normal, although the total quantity in the body is doubtless diminished. The picture is that already described under pyloric stenosis from any cause, and is not characteristic of cancer.

When the tumor is so situated that no obstruction to the passage of food occurs, the patient will suffer from digestive disturbances of a progressive character; but the effect upon the organism at large will be different. The patient may not lose much body weight, the subcutaneous fat will be to a great extent preserved, but he will be affected by a profound degree of anemia. The degree of anemia may reach a higher grade than in almost any other disease. The hemoglobin may fall to forty to thirty or even fifteen per cent of the normal amount. The color of the skin is a peculiar white, yellowish-white, or gray. Edema of the feet and legs is often present. The general appearance of these patients is typical of the cancerous cachexia. They become feeble, weak, and very miserable. As pointed out by von Mikulicz, a pretty severe grade of anemia may exist in these cases, and yet they may still be amenable to operation, assuming that the local disease has not advanced too far—i. e., a generally cachectic appearance is not in itself an absolute contraindication to operation.

Digestive Disturbances.—The digestive disturbances produced by cancer of the stomach are, in the early stages, simply those of gastric dyspepsia. The

patients suffer from loss of appetite, usually absolute; they have a coated tongue, a bad taste in the mouth; pyrosis. In about ninety per cent of the cases there is vomiting. The character of the vomiting varies in different cases. In cancer of the pylorus vomiting is often the first symptom to attract the patient's attention, and is due to pyloric stenosis. The vomiting may come on at once after eating or be delayed for an hour or two; or at first the patients may only vomit every other day or once a week. The vomited material will early show the characters of motor insufficiency of the stomach. Except in those cases in which cancer is grafted on the base of a chronic ulcer, there will in most cases be absence of free HCl in the vomited material and lactic-acid fermentation. As already noted, in those cases of cancer following ulcer of the stomach, HCl may be increased or normal throughout the disease; in these, lactic-acid fermentation will be absent. As the disease progresses, vomiting usually becomes a more frequent and marked symptom.

In cancers of the lesser curvature or other portion of the stomach not causing obstruction to the passage of food, although commonly attended by vomiting, the symptom is apt not to be so prominent nor so early in its appearance; it may be absent. Carcinoma of the cardia causing obstruction is attended by speedy or immediate regurgitation of food. When no such obstruction exists, the disease may run a latent course; for a long period no vomiting may occur. Of the symptom vomiting it must then be said that it is very variable, and cannot be regarded as in any way characteristic. In some cases vomiting may be present for a number of weeks and then subside, so that the patient no longer vomits for a considerable period. In other cases there will be no vomiting at all until shortly before the patient's death.

Pain.—Although pain is a very constant symptom of cancer of the stomach, since it is present in more than ninety per cent of the cases; it cannot be said to be a characteristic symptom. It is often present after eating as a dull, constant pain in the stomach, or in other cases a similar pain may be present all the time, irrespective of the ingestion of food. In other cases the pain will occur in sharp severe attacks, referred to the site of the cancer in the stomach and radiating in various directions. As the disease progresses the pain is apt to grow more severe.

Gastric Motility.—Nearly all cases of cancer of the stomach, with very rare exceptions, exhibit sooner or later marked evidences of motor insufficiency; i. e., retention and stagnation of food for abnormal periods. The cases may be grouped in two classes: Cases of pyloric cancer or of cancers of the lesser curvature, involving the pylorus and causing obstruction, exhibit marked evidences of loss of motor function early in the disease. Cases not causing obstruction, no matter where situated, exhibit the same signs in a lesser degree and at a later period of the disease, as a result of the general atony of the stomach wall, including both mucous and muscular coats.

Changes in the Secretion of the Stomach.—In most cases of carcinoma of the stomach, atony of the mucosa and the lesions of chronic gastritis occur

early in the disease. The secretion of HCl is speedily diminished, and in a large proportion of cases disappears as free HCl, although a diminished quantity appears still in combination. The ferment pepsin is also diminished, although to a less extent and less rapidly than HCl. As already noted, an exception occurs in those cases of chronic ulcer of the stomach with implantation of carcinoma upon the base of the ulcer. In these, excess of HCl may be present throughout the disease or disappear only at a very late period. Along with disappearance of HCl there occur fermentative changes in the stomach, increase of bacteria, sarcinæ, and notably lactic-acid fermentation. The presence of lactic acid is regarded by most observers as highly suggestive of carcinoma, since it occurs only rarely in other conditions, primary gastric atony with severe chronic gastritis alone excepted. (Butyric and acetic-acid fermentation may also occur, but are not signs of marked diagnostic value.) Unfortunately, the appearance of lactic-acid fermentation is not often an early symptom; usually the diagnosis can be made by other signs and symptoms before this sign appears; the formation of a tumor, cachexia, symptoms of marked pyloric stenosis, etc., and therefore from the surgical standpoint as an early indication for radical operation it has but little value. In cases where the symptoms render the diagnosis of cancer of the stomach probable, the presence of lactic-acid fermentation is strong confirmatory evidence. Should no tumor be felt, the cancer is probably hidden beneath the costal arch in the cardia or the posterior wall of the stomach. Such cases are nearly always incurable by operation; the tumor will often be found of large size.

Bleeding.—The presence of small quantities of blood in the vomited matters is one of the most constant accompaniments of cancer of the stomach, although not always at an early stage. Large hemorrhages, such as occur from gastric ulcer, are rare. The blood may only be recognizable under the microscope as hemin crystals, or by giving the characteristic spectrum of hematin in the spectroscope. In other cases these patients will vomit a recognizable quantity of blood every day, so that in the aggregate they lose a good deal of blood in this way.

Formation of Palpable Tumor.—The presence of a palpable tumor in cases of cancer of the stomach is the most positive diagnostic sign. As already indicated, it is by no means always discoverable, and when found only too often the case has passed beyond the stage when curative operation is possible. Under favorable conditions tumors of the pylorus can be palpated, tumors of the pyloric portion of the lesser curvature sometimes. The nearer they are to the pylorus the more readily are they to be felt. Those of the greater curvature can usually be felt if not too far toward the left. Tumors of the fundus and cardia only when they have attained a large size; they may then descend far enough during deep inspiration to give a sense of resistance rather than of a distinct tumor mass.

The size of the tumor varies from that of the last joint of one's thumb to a large massive growth as large as a man's fist, or in cases of diffuse carcinoma,

involving the greater curvature, the entire greater curvature as far as palpable may be plainly outlined as the lower border of a massive tumor whose upper border is lost beneath the ribs. *The consistence.*—The sensation transmitted to the examining fingers is usually that of almost stony hardness. *The shape.*—Tumors of the pylorus often have a rounded or ovoid shape. When the lesser curvature is involved and the tumor is palpable, it may feel crescentic or sausage-shaped. A similar shape is given to tumors of the pylorus and lesser curvature when the original growth becomes fused with the secondary glandular tumors along the lesser curvature.

Tumors of the greater curvature may be of any shape—i. e., rounded, circumscribed plaques or nodules, or diffuse sausage-shaped masses, etc. Secondary involvement of the glands in gastrocolic omentum may give the lower border a nodular and uneven surface. In most cases the surface of gastric cancers feels smooth through the abdominal wall. The ease with which these tumors can be palpated varies greatly, irrespective of their situation. In the case of an individual who has still firm muscles and a well-marked panniculus, no tumor may be felt, or simply a sense of resistance; a similar tumor in the belly of a flabby, thin old woman who has borne many children may be grasped between the fingers, and if situated in the pylorus or greater curvature, and not adherent, may be moved freely here and there from one side of the belly to the other. I have in mind such a case seen a few days since: a carcinoma of the greater curvature and posterior wall near the pylorus, in the stomach of an old woman with marked gastroptosis. The mass felt as large as a hen's egg. It was, in fact, a flat plaque, circular in shape, about an inch in thickness and two inches and a half in diameter. The home of the tumor was a little to the left of the middle line at the level of the umbilicus; from here it could be moved into either flank, downward nearly to the pubes, or upward beneath the right lobe of the liver; this last movement when the tumor was pushed well beneath the liver alone caused a little pain. (For further details of the characteristic mobility of gastric tumors, see section on the Diagnosis of Tumors of the Abdomen.)

Tenderness.—The tenderness of cancers of the stomach varies greatly. The tumor may be quite insensitive. In other cases tenderness in varying degrees will be present, but will rarely be as marked as in cases of ulcer of the stomach. Tumors of the cardia and lower end of the gullet are often accompanied by tenderness on firm pressure over the lower end of the sternum.

Fever.—Fever of an irregular character may occur during the progress of the disease. It has no diagnostic significance.

The Bowels.—Constipation of the bowels is usually present in cancer of the stomach. Diarrhea sometimes occurs during the later stages of the disease.

Differential Diagnosis of Cancer of the Stomach.—As already indicated, the course of the disease and the symptoms produced by cancer of the stomach vary greatly. The cases may be broadly divided into two groups: (1) Those in which the tumor opposes no mechanical obstruction to the pas-

sage of food through the stomach. (2) Those in which such obstruction is present. The second group may be subdivided into: (*a*) Cancer of the pylorus; (*b*) cancer of the cardia.

Cancer with no Mechanical Obstruction.—The cancer may be anywhere in the stomach. It is most often on the lesser curvature, much more rarely in the fundus, sometimes in the greater curvature or posterior wall. According to its situation and size, a tumor may early be present, or there may be no palpable tumor throughout the course of the disease. These patients begin to suffer from symptoms of gastric dyspepsia, and soon present marked symptoms of chronic gastritis. They may or may not vomit. Bleeding is rarely observed early in the disease. There is absence of free HCl in the gastric contents, and later the appearance of lactic-acid fermentation. The signs of motor insufficiency are slowly developed not as the result of obstruction, but of gastric atony. The general health undergoes progressive deterioration, anemia of a severe grade develops, ending in cancerous cachexia. These patients do not necessarily become emaciated; the general drying up of the tissues seen in pyloric and cardiac obstruction is absent.

If no tumor is felt, the diagnosis is often not made until late in the disease. These patients are apt to be treated for gastritis, atonic dyspepsia, sometimes for chronic ulcer of the stomach. In some cases involvement of the liver or biliary passages or pancreas will point to disease of these structures rather than to the stomach as the origin. A massive tumor of the liver or of the gall-bladder may develop and be readily palpable, while the cancer of the stomach remains comparatively small or hidden from palpation.

Involvement of the biliary passages and pancreas will often produce jaundice, etc., and lead to a probable diagnosis of gall-stones or of primary cancer of the gall-bladder or papilla of Vater, etc. If the tumor is in the greater curvature, and involves the transverse colon, it may be difficult before opening the belly to say whether the growth is in the stomach or intestine. In this group of cases the duration of life varies from a few months to several years. As already stated, after a positive diagnosis can be made from clinical signs and symptoms, the average duration of life is one year. These patients may die of exhaustion, from interference of function caused by metastatic tumors, or from pneumonia. In a certain number of cases the disease may run its course even until a few weeks before a fatal termination with only a gradual deterioration of the general health and no marked symptoms referable to the stomach, so that the patient may not consult a physician until very late in the disease. The tumor may even occupy the pylorus and produce no obstructive symptoms until within a few days of the patient's death. In a few cases metastatic tumors may form in distant parts and produce characteristic signs and symptoms, the tumor of the stomach remaining unsuspected until autopsy.

Cancers of the Pylorus with Obstruction.—While, as stated, cancer of the pylorus does not necessarily cause obstructive symptoms, and may run its course to a fatal issue without such symptoms, the typical picture in these cases is

that of pyloric stenosis coming on early in the disease. These are the cases in which a palpable tumor is often developed very soon. A probable diagnosis can sometimes be made at a time when radical removal and cure of the disease is still possible. They are thus the cases interesting to surgeons. In another and even more frequent group of cases the growth begins in the lesser curvature and advances to the pylorus, causing obstruction. In these the formation of a palpable mass and the symptoms of pyloric obstruction are longer delayed. In the typical cases originating in the pylorus, the symptoms may be briefly recapitulated. Severe digestive disturbances come on rapidly. Frequent vomiting is a constant early symptom. The secretion of the stomach contains no free HCl. Fermentative changes occur early and are marked, notably lactic-acid fermentation. The patient emaciates rapidly. There is, as already described under pyloric stenosis, rapid diminution of body fluids and a general drying up of the system. Anemia, as indicated by tests for hemoglobin and blood counts, is not marked or is absent. The degree of dilatation varies in different cases, according to the degree of obstruction. It may be very marked or slight, even absent. (See Pyloric Stenosis.) The early formation of a pyloric tumor greatly aids the diagnosis.

It is not possible to differentiate chronic ulcer with peripyloric thickening and marked obstruction, accompanied by a dilated stomach, from chronic ulcer upon which cancer has been developed. A tumor may be present in each; in each the general nutrition may be profoundly affected. An excess of free HCl may be present in either case. In the absence of a tumor, motor insufficiency due to primary gastric atony may lead to an error in diagnosis. This condition is much more rare than cancer. The symptoms and signs are not in the same sense distinctly progressive, as in cancer. The other benign causes of pyloric stenosis, ulcer, pressure upon the pylorus by tumors or by acute or chronic exudates (perigastritis); further, obstruction of the pylorus or duodenum in gastroptosis due to angulation must be considered. The diagnosis of these conditions has already been spoken of. The chemical and microscopic examination of the gastric contents furnishes valuable aid in these cases. As stated at the beginning of this section, it is usually difficult, frequently impossible, to make an early positive diagnosis of gastric cancer without an incision. Progressive dyspeptic symptoms in an individual during the cancer age, such that the local and general signs and symptoms render a diagnosis of cancer probable, are a sufficient indication for a small exploratory incision.

Cancer of the Cardia.—Cancer of the cardia causing obstruction presents the signs and symptoms of cancer of the lower end of the esophagus or of cardiospasm. The lower end of the gullet often becomes much dilated. These patients suffer the same sort of disturbance of nutrition as accompanies pyloric stenosis —i. e., they undergo more or less rapid starvation. As the obstruction becomes more marked, inability to swallow food or the immediate regurgitation of the food swallowed becomes a prominent symptom. As already stated, pain and tenderness on pressure felt behind the lower part of the sternum is regularly

present. If the obstruction continues, death from starvation is the result. In some cases the obstruction will be temporarily relieved by ulceration and sloughing of the tumor tissue. Many cases of cancer of the cardia or cardiac portion of the stomach cause no obstruction, the disease may run an almost entirely latent course, no tumor can be felt in any case, and the esophageal bougie passes into the stomach without difficulty. The patients suffer from the symptoms of gastric dyspepsia, and sooner or later become cachectic. In some cases it has been possible to make the correct diagnosis with the esophagoscope. Occasionally the eye of a stomach-tube introduced for diagnostic purposes may bring away a fragment of tumor tissue.

Examination of the Gastric Contents.—While the surgeon will rarely if ever analyze the contents of the stomach himself, but will nearly always place this task in the hands of a skilled pathologist, the following brief description of the method of determining hydrochloric acid and lactic acid may be useful to those who have not access to a pathological laboratory. The details are quoted by permission from F. E. Sondern: As has already been noted in discussing the diseases of the stomach, absence of hydrochloric acid in the presence of other concomitant signs and symptoms suggests the presence of cancer, but by no means proves it; nor does a very high percentage of hydrochloric acid prove the presence of ulcer of the stomach. The presence of lactic acid is suggestive of cancer, and occurs perhaps rarely in other conditions, still it cannot be considered as conclusive evidence of cancerous disease. In this regard it may be stated, as with reference to other surgical conditions, the diagnosis is rarely to be made by the laboratory findings alone. The ordinary methods of clinical observation, the careful physical examination of the patient, and a comprehensive history of the case will always remain our most important aids at arriving at a proper diagnosis. The laboratory findings, while at times very valuable, are at best but confirmatory evidence.

Method of Gastric Analysis.—The procedure is as follows:[1]

The patient is given an Ewald test breakfast, consisting of one baker's roll, without butter, weighing about 35 gms., and 300 c.c. of water or weak tea without milk or sugar, on an empty stomach. One hour after ingestion the contents of the stomach are expressed by tube without the use of water. While a more elaborate examination may be useful, at least the following determinations should be made:

Total quantity (normal, 40 c.c. to 200 c.c.).

Total quantity of filtrate (normal, 20 c.c. to 140 c.c.).

Free hydrochloric acid (normally present).

Lactic acid (normally absent).

Total acidity (normal, 1.5 to 3.0 gms. per mille). Scheme "A."

Total hydrochloric acid (normal, 1.15 to 2.18 gms. per mille). Scheme "E."

Total free hydrochloric acid (normal, 0.09 to 1.09 gms. per mille). Scheme "D."

[1] F. E. Sondern, "Fowler's Surgery." W. B. Saunders Company.

Total combined hydrochloric acid (normal, 0.24 to 1.49 gms. per mille). Scheme "C."

Total acidity due to organic acids and acid salts (normal, 0.2 to 0.88 gm. per mille). Scheme "F."

Presence of free hydrochloric acid (*vide infra*) is most easily demonstrated with Töpfer's test. The addition of one or two drops of 0.5 per cent alcoholic solution of dimethyl-amido-azo-benzol to a small amount of gastric contents immediately produces a bright cherry-red color if free hydrochloric acid is present. This test is preferable to others on account of its delicacy and the stability of the reagent. Lactic acid, if present in considerable amount, will produce an orange color; but if any doubt exists, the lactid acid can be removed by treating the specimen with ether before the test for free hydrochloric acid is applied.

Presence of lactic acid in sufficient amount to be of clinical importance can be demonstrated by the Strauss test. The graduated separating funnel is filled to the 5 c.c. mark with filtered gastric contents, pure ether is added to the 25 c.c. mark, and this is thoroughly shaken. After the liquids have separated, the stopcock is opened and all but 5 c.c. allowed to escape. Distilled water is now added to the 25 c.c. mark, shaken, and followed by two drops of the reagent, consisting of a freshly made 1 to 10 dilution of tincture of ferric chlorid in water. The presence of lactic acid is shown by a decided green color.

Schemes.—"A." Total acidity.—To 10 c.c. filtered gastric contents add 2 drops of 1 per cent alcoholic solution phenolphthalein (indicator). Titrate with $\frac{1}{10}$ normal sodium hydrate. For example, 7 c.c. $\frac{1}{10}$ N.NaOH used. $7 \times 0.00365 = 0.0255$ gm. total acidity in 10 c.c. gastric contents, expressed as HCl. $0.0255 \times 100 = 2.55$ gms. total acidity per mille (per thousand).

"B." Free acids and acid salts.—To 10 c.c. filtered gastric contents add 2 to 3 drops 1 per cent aqueous solution sodium alizarin sulfonate (indicator). Titrate with $\frac{1}{10}$ normal sodium hydrate. For example, 4.9 c.c. $\frac{1}{10}$ N.NaOH used. $4.9 \times 0.00365 = 0.0178$ gm. total free acids and acid salts in 10 c.c. gastric contents, expressed as HCl. $0.0178 \times 100 = 1.78$ gms. total free acids and acid salts per mille (per thousand).

"C." Total combined hydrochloric acid.—"A," as above, 2.55 minus "B," as above, $1.78 = 0.77$ gm. total combined hydrochloric acid per mille (per thousand).

"D." Total free hydrochloric acid.—To 10 c.c. filtered gastric contents add a few drops of 0.5 per cent alcoholic solution dimethyl-amido-azo-benzol (indicator). Titrate with $\frac{1}{10}$ normal sodium hydrate. For example, 3.1 c.c. $\frac{1}{10}$ N.NaOH used. $3.1 \times 0.00365 = 0.0113$ gm. total free hydrochloric acid in 10 c.c. gastric contents. $0.0113 \times 100 = 1.13$ gms. total free hydrochloric acid per mille (per thousand).

"E." Total hydrochloric acid.—"C," as above, 0.77 plus "D," as above, $1.13 = 1.90$ gms. total hydrochloric acid per mille (per thousand).

"F." Total acidity due to organic acids and acid salts.—"B," as above, 1.78 minus "D," as above, $1.13 = 0.65$ gm. total acidity due to organic acids and acid salts per mille (per thousand).

Sarcoma of the Stomach.—Sarcoma of the stomach is more frequently a metastatic growth secondary to sarcoma in some other part of the body, notably in cases of melano-sarcoma and the small round-celled form. As a primary

tumor Fenwick estimated that sarcoma constituted from five to eight per cent of the primary tumors of the stomach. Several forms have been observed—round-celled, spindle-celled, and mixed forms. The disease may occur at any time of life, but is more common in males under thirty-five years of age. Any part of the stomach may be the seat of the disease. The cardiac and pyloric orifices are less often attacked than is the case with cancer. Ulceration is less common than in cases of cancer. The tumor may have the form of a rounded nodule or a massive plaque, and may attain a large size. Thus, Cantwell ("Annals of Surgery," November, 1899) reports the removal of a spindle-celled sarcoma weighing twelve pounds. In some of the operated cases the tumor has been circumscribed and easily removable; in others a diffuse infiltration of the stomach wall has rendered removal impossible. The duration of life is short, about one year from the beginning of definite symptoms. In the case of primary sarcoma of the stomach there is no means of making a differential diagnosis from carcinoma before operation. Indeed, the macroscopic appearances of the tumor on section may be identical in the two conditions.

Benign Tumors of the Stomach.—Various forms of benign tumor are observed in the stomach. They rarely produce important symptoms or signs unless they obstruct the pylorus or are discovered accidentally by palpation. Among the epithelial new growths of a benign character may be mentioned adenoma and adenofibroma. They occur as sessile or pedunculated growths, usually near the pylorus. They are often multiple. If pedunculated, this as well as other forms of benign growth may act as a ball valve, and thus cause symptoms of obstruction at the pylorus. They are believed sometimes to undergo cancerous degeneration. Among the connective-tissue group of tumors may be mentioned lipoma, fibroma, fibro-lipoma, myoma, and lymphadenoma. These tumors are not very rare, but in a large proportion of cases cause no symptoms. The myomata have more often attained a considerable size, so as to be recognized and operated upon than the other forms. They occur along the greater and lesser curvatures rather than at the pylorus. Originating in the muscular coat of the stomach they may grow in such a way as to project into the cavity of the stomach, or outwardly, so as to project into surrounding peritoneal cavity. Those projecting into the stomach may give rise to digestive disturbances, or may ulcerate, bleed, and cause hematemesis. The subperitoneal forms are more likely to form palpable tumors. In the absence of serious gastric disturbances, and with a history of the prolonged presence of the tumor, it might be possible to make a probable diagnosis of benignancy. The operative removal of the tumor would usually be necessary for a diagnosis.

CHAPTER III

SURGICAL DISEASES OF THE INTESTINE

CONGENITAL ABNORMALITIES OF THE INTESTINE

Meckel's Diverticulum.—The formation of Meckel's diverticulum has already been described under "Omphalomesenteric fistula." It is the most frequent form of congenital anomaly found in the intestine, and it occurs more or less distinctly marked in one individual in fifty. The seat of the pouch is variable. It is always connected with the ileum at a distance from the cecum, which varies within rather wide limits. G. S. Huntington examined 22 cases with reference to this point; the distance of the diverticulum from the cecum varied between 27.5 cm. as a minimum and 290 cm. as a maximum. The average distance was 107 cm., about 45 inches. The size and shape of the pouch varies. It may form a slight protrusion, merely, of the wall of the gut opposite its mesenteric attachment, or a sausage-shaped pouch many inches in length, as large as the small intestine. It may be conical, dilated into a considerable sac at its distal end or strictured. It may resemble in size and shape a vermiform appendix. The caliber may be open as far as or be attached to the umbilicus. The extremity may be free, attached by a fibrous cord to the umbilicus, or to some other part of the parietal or visceral peritoneum.

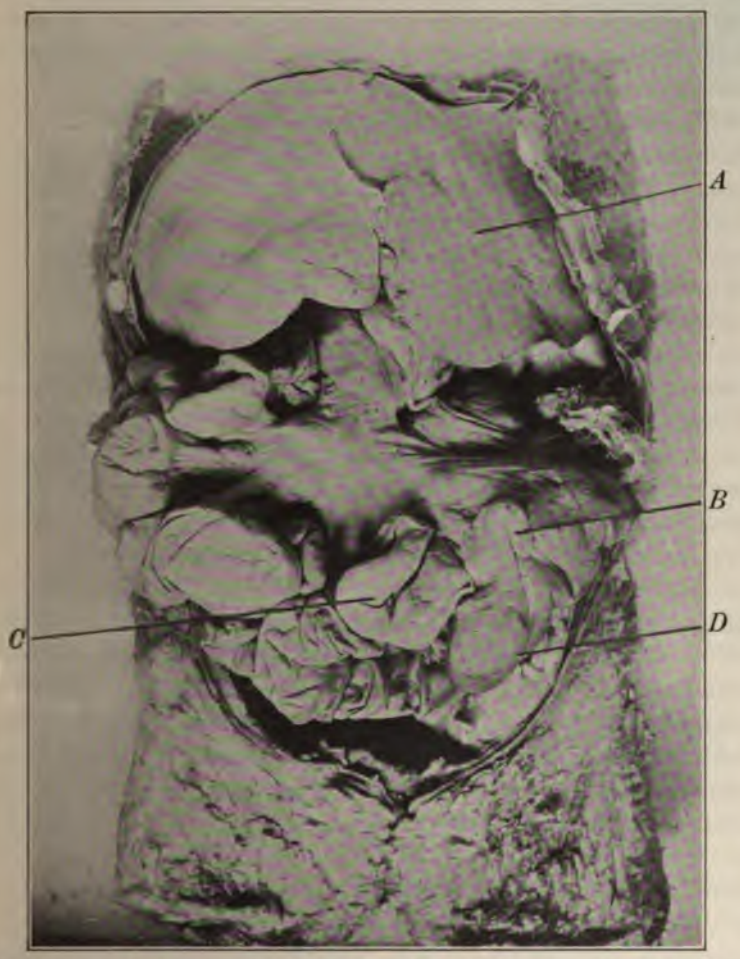
Meckel's diverticulum may be of surgical interest in several ways: (1) It may form the contents of a hernial sac, and become adherent or strangulated, producing the symptoms of strangulated hernia of a portion of the wall of the gut. (2) It may very rarely become strictured and inflamed or gangrenous precisely in the same way as the vermiform appendix, producing signs and symptoms scarcely to be differentiated from acute appendicitis, except that the point of extreme tenderness would be situated farther to the left. (3) It may be the seat of lodgment of a foreign body; pressure ulceration and perforation peritonitis may result as in group 2. (4) It may, and this condition is much more common than any of the other possibilities mentioned, be the cause of intestinal obstruction.

If free, it may become looped or knotted about a coil of small intestine, and occlude its caliber. It may become adherent by its tip to any neighboring portion of peritoneum, thus forming an orifice through which coils of gut pass and become constricted. I have seen two cases of acute intestinal obstruction produced in this way. (See Intestinal Obstruction.) In neither case did the

fibrous cord extend to the umbilicus. In one a band passed from the tip of the diverticulum to the mesentery of the small intestine; in the other a short fibrous cord connected a small diverticulum with the anterior abdominal wall to the right of the median line.

Other Congenital Deformities.—A variety of congenital deformities and defects occur in the intestine. They consist of narrowings or atresias, of absence of portions of intestine, sometimes of an increase in length or caliber of certain portions of gut; further, of malpositions of various kinds, due to the fact that the normal evolution of the gut has been arrested at some part of its course, or has proceeded along abnormal lines. Some of the congenital defects are incompatible with the continuance of life; some can be recognized and relieved by surgery, after birth; some produce no symptoms; some may lead to errors in diagnosis of intra-abdominal diseases occurring during later years; some to unexpected dangers and difficulties during abdominal operations. A few only of these conditions demand description in a work on surgical diagnosis. Congenital atresias and stenoses may occur at any point of the intestine. There are certain points of predilection, the rectum and anus being by far the most frequent seat. (See Rectum.) Next in frequency is the site of the omphalomesenteric duct in the ileum. Atresia or stenosis of the duodenum has been observed in a fairly large number of cases. The seat of the closure or stenosis has in most cases been above the papilla. In a personal communication G. S. Huntington informs me that he has recently seen a case in the body of a new-born child in which the duodenum was closed 4.5 cm. from the pylorus—i. e., below the papilla. It is possible that such conditions might be recognized during life. For example, continued vomiting in a new-born infant, while meconium continued to be passed *per rectum*, would suggest atresia of the duodenum above the papilla. Such a child would be able to swallow food in quantity; vomiting might be delayed for a time. If the atresia was below the papilla, the child would probably vomit bile. Congenital stenoses of the *large intestine* are, except at its lower end, rare. A few cases have been observed of congenital angulation of the sigmoid with obstructive symptoms. A number of cases have been reported of congenital enlargement, both in length and caliber, of the sigmoid, so that this portion of the gut has become enormously dilated during childhood, and has filled a large part of the abdomen. When the mesentery of the sigmoid is unusually long the conditions are favorable for the formation of volvulus; this occurs more commonly during the later years of life. Certain racial peculiarities are observed in the length of the small intestine. It is sometimes much longer among peoples who live exclusively on a coarse vegetable diet than among those who live exclusively upon animal food. Russian peasants and Eskimo respectively. Total transposition of the thoracic and abdominal viscera is occasionally observed. Total transposition of the abdominal viscera does not occur without a similar condition in the thorax. A photograph of an unusual arrangement of the intestines is here reproduced through the kindness of Prof. G. S. Huntington, who has observed

veral similar cases. This subject was an infant, two years old, in whom e normal rotation of the large intestine from left to right had not occurred. he small intestine and the large intestine as far as the beginning of the scending colon hang free in the abdominal cavity, suspended by a long mes-



21.—The Abdominal Viscera of a Child Aged Two Years. Preparation in the Anatomical Department of the College of Physicians and Surgeons of Columbia University. This is an example of nonrotation of the gut. *A*. The left lobe of the liver. *B*. Vermiform appendix. *C*. The ileum entering the cecum from right to left. *D*. Cecum.

ery, whose point of attachment is high up in the abdomen, the cecum and endix are in the left iliac region. The appendix lies on the front of the im just beneath the abdominal wall. The ileo-colic entrance is from right eft. In the event of appendicitis in such a case the anatomical arrangement ld be puzzling to the surgeon. (Blake has operated upon two such cases.) perated upon such a case in 1907, a boy with acute appendicitis. The ngement of the intestine and mesentery, as well as the position of the ap-

pendix resembled that of the subject shown in the illustration, except that the appendix extended downward into the pelvic cavity. The appendix was perforated. There was a localized abscess. The patient recovered. In this case the large intestine lies in front of the small intestine. The opposite condition had been observed—i. e., the transverse colon has been found running across the back of the abdomen with the duodenum in front of it. Various anomalies are observed in the *cecum* and *ascending colon.* In very rare cases the ascending colon may be absent; the cecum and vermiform appendix will then be found tucked up beneath the liver. The *cecum* may be abnormally long, and with its attached appendix may be found in various situations, sometimes folded upward upon itself, so that again the appendix will be found beneath the liver or at any intermediate point down to its normal site. The *transverse colon* may be greatly lengthened and form a long loop, hanging down as far as the pubes. The angle made by the dependent loop with transverse portion is often acute and favors the occurrence of twists. The *sigmoid* shows greater variations in length than the other portions of the large intestine, and is the favorite seat of volvulus. It may form one or several curved loops, extending across to the right iliac region or upward as far as the diaphragm, or in other directions. I operated upon an old man for volvulus of the sigmoid, in whom this portion of intestine was more than a yard in length as well as enormously dilated and thickened, the average normal length of the sigmoid being about eight or ten inches. The ascending or descending colon, or both, may be absent. The large intestine may then pass from beneath the liver downward obliquely across the belly from right to left. The large intestine may be of considerable length, but fail to show its normal curves; it may then form an irregular coil or coils, ending below in the rectum. The ascending and descending colon may possess a considerable mesentery. Among the anomalies of the mesentery of the small intestine may be mentioned: the mesentery of the upper portion of the jejunum may be absent or that of the lower portion of the ileum; the longitudinal muscular bands of the colon may extend for a certain distance along the ileum. The mesentery of the small intestine may have only a limited attachment above and not extend downward as far as it should, as in the case shown in the illustration of nonrotation of the gut. Volvulus of the entire small intestine is thus favored. The mesentery of the small intestine may be very long, thus favoring volvulus or axial rotation of single coils or obstruction of the duodenum by the mesenteric artery when such small intestines fall or are crowded down into the pelvis.

Diverticula other than those mentioned are occasionally observed in both large and small intestine, and, though they cannot be diagnosticated until operation or autopsy, deserve mention, because when they produce symptoms and lead to operative interference the surgeon should be acquainted with all possibilities. They may be divided into two groups: small multiple diverticula, rarely, if ever, causing symptoms, and large diverticula, usually single, although occasionally several may be observed in the same case, from whose presence

serious symptoms may arise. These diverticula may be further classified, according to whether all the coats of the intestine are involved in the dilatation (*true diverticula*) or whether a hernia of the mucous coat occurs through a weakened muscular coat, and forms a pouch of greater or less size consisting merely of mucosa and peritoneum (*false diverticula*). Diverticula may be either congenital or acquired, although in the given case it may be difficult to separate the two classes. The congenital forms include all the layers of the intestinal wall. The acquired forms may or may not. In the acquired forms the localized dilatation may be produced by pressure from within the gut, due to ulcerative or other condition, gall-stones, foreign bodies, etc., causing a weak place in the intestinal wall or to traction from without, due to adhesions, bands, etc., of whatever character. Although diverticula may occur at any point as the result of traction from without, those due to pressure from within are more apt to occur in certain situations, notably in those situations where veins leave or a duct enters the intestine in parts of the intestine not covered by peritoneum—for example, the posterior wall of the descending portion of the duodenum. Such diverticula are usually small. The large diverticula occur most often in the large intestine, more often in the sigmoid flexure than elsewhere. True diverticula of unknown causation have been observed here of enormous size. They have given symptoms when filled with impacted feces, causing an abdominal tumor. The small multiple diverticula of small intestine, as stated, rarely cause symptoms. Conditions have, however, been observed associated with the presence of such diverticula in the large gut of a peculiar character. Marked inflammatory thickening of the wall of the gut, narrowing of its caliber, hardening of its walls, and adhesive peritonitis. The larger diverticula may give rise to symptoms in various ways. In the colon they may become distended with feces, cause pressure symptoms, even obstruction of other coils of intestine. They may be the seats of lodgment of foreign bodies or the home of enteroliths or large gall-stones. Pressure necrosis, ulceration, and perforation of the bowel may thus occur, with localized or general peritonitis, etc.

INTESTINAL OBSTRUCTION

Intestinal obstruction occurs in two forms, chronic and acute. Chronic obstruction is, of course, incomplete; when complete, the clinical picture changes at once to that of the acute form. Acute obstruction is often characterized by the general title **Ileus**, a condition presenting a definite symptom-complex, though due to many and diverse causes and produced in a variety of ways. It is to be borne in mind that chronic obstruction of the gut often becomes suddenly acute, as when a portion of intestine, already narrowed, is occluded by a foreign body, a mass of hardened feces, or by pressure from without from a tumor, an inflammatory exudate, a kink in the intestine, etc. Such occlusion may be but temporary, and the symptoms may again return to the chronic form. Further, it may be said that very considerable degrees of stenosis may

exist, notably in the small intestine, when the contents are fluid without producing any symptoms. In the colon, on the other hand, the contents being normally solid or semisolid, slighter degrees of stenosis may cause marked symptoms, yet it is astonishing to observe how much the caliber of even a large portion of the colon may be reduced without producing very marked symptoms. Thus, in a personal communication from C. F. Collins, I learned recently of a case of his own where the colon was reduced by a chronic inflammatory process probably to a caliber no larger than a lead pencil. Constipation had never been so marked as to cause alarming symptoms, and was controlled readily enough by internal medication. Death was due in this case to another cause.

Causation.—Chronic stenosis of the bowel may be due to intrinsic or extrinsic causes. Among the former are included tumors of the bowel, ulcerative processes, and cicatricial contraction of the caliber of the gut, foreign bodies, and invagination (intussusception). Among the latter, tumors and exudates pressing upon the bowel from without, adhesions causing kinks or pressing upon and narrowing the lumen of the gut.

Changes in the Bowel above and below the Point of Stenosis.—In any case as the bowel becomes narrowed to such a degree as to interfere with the onward passage of its contents there occurs here, as in other hollow muscular organs, compensatory hypertrophy and increased muscular activity of the portion of intestine lying above the obstruction. This may be efficient for a considerable length of time to overcome the mechanical obstacle. Sooner or later dilatation and muscular atony follow, and thus the intestine above the obstruction is increased in caliber. The dilated bowel extends for a variable distance above the obstructed point. Its walls are thickened, but its muscular activity is feeble. This dilatation varies in degree. It may be only moderate; in other cases, notably in slowly contracting tumors of the intestine, it may reach large proportions. Thus I have seen a case of carcinoma of the splenic flexure of the colon in which obstructive symptoms had been slowly increasing for many months in which the ascending and transverse colon were at least four inches in diameter, and filled the greater part of the distended abdominal cavity. A similar case was observed in my service at the New York Hospital in January, 1909. In this case the obstruction was very chronic, and due to cicatricial stenosis of the gut. Very marked dilatations may also be observed in the small gut. The portion of intestine below the obstruction, on the other hand, usually undergoes a degree of narrowing directly proportionate to the grade of stenosis at the obstructed point. In certain cases this narrowing is very marked indeed; in others, the gut may preserve almost its normal size.

Signs and Symptoms.—The signs and symptoms of chronic obstruction vary much, being modified not only by the DEGREE OF STENOSIS, but also by its ANATOMICAL SITE. The clinical picture of stenosis of the duodenum differs from that of stenosis of the middle portion of the small gut, jejunum, and ileum, and that again from stenosis of the large intestine. Stenosis of the duodenum

may occur: (1) Above the papilla; (2) at the level of the papilla, causing, in addition, interference with the flow of bile and pancreatic juice; (3) below the papilla. The signs and symptoms will differ in each case.

1. *Stenosis above the Papilla.*—Stenosis above the papilla produces symptoms chiefly referable to the stomach. If the stenosis is of a high grade, the stomach becomes dilated, the pylorus incompetent, and the duodenum dilated above the obstruction. The condition is hardly to be distinguished from pyloric stenosis. There will be vomiting of large quantities of food at considerable intervals, fermentative changes in the contents of the stomach, emaciation, etc., as already described under pyloric stenosis.

2. *Stenosis at the Level of the Papilla.*—Stenosis at the level of the papilla frequently accompanies carcinoma of the duodenum, sometimes cicatricial contraction following ulcer. If the orifice of the duct is obstructed, the patient will suffer from chronic jaundice, occasionally from attacks of pain resembling biliary colic from gall-stones. In the recorded cases the signs of distention of the gall-bladder have not been marked. The urine will contain bile pigment, the stools will be pasty and clay-colored; they may contain free fat; there may be glycosuria. It will usually be impossible before operation to make an exact diagnosis. Disease of the pancreas, carcinoma, primary in the gall-bladder, or cholelithiasis with lodgment of a stone in the common duct—all may present similar symptoms.

3. *Stenosis of the Duodenum below the Papilla.*—In this condition the bile and pancreatic juice readily enter the intestine, but pass on through the narrowed portion with more or less difficulty. If the stenosis is of a high grade, bile in greater or less quantity will regurgitate into the stomach. There will be, in addition, a dilated stomach, signs of motor insufficiency of a more or less marked grade, and a phenomenon resembling that observed in hour-glass contraction of the stomach—i. e., if the stomach be washed clean, a sudden subsequent flow of fluid may occur; the distinguishing character of this fluid will be its distinctly biliary character, thus differentiating it from the foul material free from bile sometimes obtainable by this procedure in hour-glass contraction of the stomach.

General Symptoms.—It is clear from the foregoing outline that the clinical symptoms of stenosis of the duodenum with the exception of those cases causing obstruction of the biliary and pancreatic duct resemble rather affections of the stomach than of the intestine. Only in cases of very marked stenosis does the stomach dilate, and rarely, if ever, does the dilatation of the duodenum itself give rise to definite and recognizable physical signs. The patients all suffer from marked symptoms of dyspepsia, pyrosis, belching of wind and attacks of vomiting, more or less frequent. Fermentative changes in the vomited material will be more or less marked, according to the degree of interference with the passage of food. They develop absolute loss of appetite, and suffer from *severe attacks of colicky pain*, such that, though anxious to eat, the fear of certain suffering to follow renders them unable to swallow suffi-

cient food. The general health suffers in consequence, often slowly, but surely; they become emaciated, weak, neurasthenic, and miserable. *The symptoms of stenosis of the upper part of the jejunum* resemble more or less closely obstruction of the duodenum; the gastric disturbances are prominent. The lower down in the small intestine the obstruction lies the less the stomach symptoms are in evidence. Vomiting, however, continues to occur in stenosis of the small gut, no matter where situated, if at all narrow. It is to be remembered that vomiting of a fecal character may occur even when obstruction exists high up in the small intestine. The stagnation of the contents of the bowel, the imperfect bactericidal action of the gastric juice from disordered gastric digestion, favor multiplication of bacteria and stinking decomposition of the contents of the gut above the stricture. Some regurgitation of this material into the stomach is common even when the stenosis is not of a very high grade. When for any reason obstruction becomes temporarily complete distinctly fecal vomiting is the rule, even though the obstruction is not far below the stomach. If the obstruction remains permanent, the other signs and symptoms of acute intestinal obstruction follow at once. If it is finally overcome, the fecal vomiting will subside. Only when situated some little distance from the duodenum do the really characteristic local signs and symptoms of chronic intestinal obstruction become marked. They are, in addition to the *colicky pains, localized tympanites,* the occurrence of *visible and palpable peristaltic waves in a definite uniform portion of the abdomen, and the occurrence of intermittent rigid contractions of the wall of the bowel, recognized by palpation, sometimes aided by inspection.*

It goes without saying that these phenomena are more readily appreciated when the abdominal wall is thin and relaxed. Under normal conditions the intestines never become visible as distinct coils through an abdominal wall of normal thickness. In cases of ventral hernia or separation of the recti, separate coils may be visible; on palpation they feel entirely soft and yielding. In cases of chronic obstruction the distinctness of the physical signs will depend upon the situation of the stricture; the degree of stenosis, the degree of hypertrophy of the wall of the gut above the stricture; the thickness of the abdominal wall. When the abdominal wall is fairly thin, and the stenosis marked and not too near the duodenum, the phenomena may occur in one of two forms. Each is regularly accompanied by attacks of colicky pain, rarely absent, and may be followed by vomiting from regurgitation of intestinal contents into the stomach from unavailing efforts on the part of the gut to force its contents through the stricture. In the *first form* rhythmical contractions of the visible coils of distended gut occur, beginning always at the same point, and ending at some other point, indicating the position of the stricture. The peristaltic movements are accompanied by pain. On percussion the distended coils give a high-pitched tympanitic resonance. On auscultation gurgling sounds can often be heard, or they may be distinctly audible from a distance. They are distinctly appreciated by the patient. Succussion

splashing sounds may sometimes be elicited. These phenomena are observed over a greater or less area of the abdomen, according to the length of gut involved. They begin and end at definite points in the abdomen, and these points are the same in each attack. In less well-marked cases the individual coils may not be distinguishable, but simply a more or less definite area of abdominal swelling, accompanied by pain and the other signs, appearing intermittently at intervals of seconds or minutes. These phenomena may occur spontaneously; they may follow the ingestion of food, psychical disturbances, or local irritations of the abdominal wall, whether mechanical or from exposure to heat or cold. Their recurrence in a uniform definite area serves to distinguish them from the somewhat rare localized tympanitic distention and peristaltic activity observed in hysterical and neurotic patients. In these cases localized tympany may occur, but its situation will be variable, changing its position from time to time, and appearing in different portions of the abdomen. The *second* form consists of a rigid tonic contraction of one or several coils of gut, coming on spontaneously or from the same causes as the first form. The contraction usually comes on quite suddenly, and is accompanied by an attack of colicky pain. If the abdominal wall is not too thick, one or several coils of intestine suddenly become visible as sausage-shaped tumors beneath the abdominal wall, upon palpation the gut can be felt as a firm cylindrical mass. The accompanying signs and symptoms resemble the first form. The contraction lasts for seconds or a minute or two, and then subsides; the contracted coils of gut suddenly disappear. *This sign is quite characteristic of marked stenosis of the small intestine.*

The movements of the bowels in chronic intestinal obstruction of the small gut show nothing characteristic. The movements are diminished in quantity, according to the degree of stenosis, the frequency of vomiting, the quantity of food which actually passes the stricture, and usually there is constipation. If catarrhal inflammation of the colon exists as a complication there may be diarrhœa. The nearer the obstruction lies to the ileo-colic junction the more the symptoms will simulate obstruction of the large bowel.

The urine is diminished in quantity, and, as is regularly the case when retention of the contents of the bowel and excessive putrefactive changes coexist, *indican* will be found in the urine in an increased quantity.

Chronic Obstruction of the Large Intestine

The signs and symptoms of stenosis of the large intestine vary a good deal, according to the situation of the obstruction. The nearer it is to the ileo-cecal valve the more the signs will resemble obstruction of the small gut. When situated in the cecum or first part of the ascending colon, a greater or less portion of the ileum will become hypertrophied and dilated, and the signs of visible peristalsis or hardening of the bowel, as already described, will be observed; further, if in the cecum, there will usually be a palpable tumor in the

right iliac fossa, carcinoma or tuberculosis of the gut being the commonest causes of chronic obstruction in this region. When, however, the obstruction is far removed from this point, the characteristic signs of active peristalsis will be absent, and the disease, for reasons about to be explained, will be far more likely to run a latent course long unrecognized. The peristaltic movements of the small gut are far more active than those of the colon. In the latter they are slower, less frequent, and less vigorous, consequently signs of active movement and intense local irritation rarely appear until the obstruction becomes suddenly absolute. The contents of the colon often slowly accumulate above the obstruction, and may give the signs of fecal impaction. The patient may suffer from severe constipation; often there will be moderate general tympanites. There may be diarrhea from catarrhal inflammation of the colon above and below the obstruction; sometimes diarrhea and constipation will alternate. The diarrheal movements are often preceded by attacks of colicky pain, or such attacks may occur at intervals without diarrhea. If the process be an ulcerative one, pus, blood, or fragments of tumor tissue in the diarrheal movements may furnish a clew to the condition. Very often the diarrheal movements on account of putrefactive changes taking place in the distended bowel above the obstruction will be horribly offensive. If the obstruction is in the sigmoid there may be a band of tympanitic resonance in each flank. If the obstruction lies in the splenic flexure or transverse colon, such an area of tympanites may be confined to the right side. The information to be derived in these cases by inflation of the bowel with air or water is sometimes valuable. (See Diagnosis of Diseases of the Abdomen.) A good many cases of chronic obstruction of the large intestine are treated for constipation, for diarrhea, for colitis, etc., for a long time before the diagnosis is made; very often it is only made upon opening the abdomen for the relief of a sudden attack of acute intestinal obstruction or for perforation peritonitis, the existence of a chronic stenosis of the gut having been entirely unsuspected. Unless the obstruction is as low as the beginning of the rectum, no valuable information is to be derived from the shape of the stools. The tapelike stools which sometimes occur in cancer of the rectum itself are not observed in obstruction of the large intestine. The effect of chronic intestinal stenosis of a grade sufficient to produce symptoms upon the general health of the individual varies as may be gathered from the foregoing paragraphs, widely in different cases. In cases due to malignant disease of the gut or to *progressive processes* of any sort, extensive ulceration due to syphilis or tuberculosis with cicatricial contraction, the result is inevitable death after a longer or shorter period, the end coming as the result of complete obstruction or from pressure perforation above the stricture and peritonitis, unless the condition be relieved by a radical or palliative operation. In other cases of a character not so essentially progressive the patients may drag out a miserable existence for many years, suffering from digestive disturbances, vomiting, constipation, diarrhea, abdominal pain, emaciation, anemia, chronic autointoxication from absorption of poisonous produc-

from the bowel, neurasthenia, and general wretchedness. Under the most favorable conditions of hygiene and diet the outlook is grave unless surgical relief is possible.

Acute Intestinal Obstruction; Ileus

Acute stoppage of the bowels may be due to two entirely different sets of conditions: In the first there is no actual mechanical closure of the lumen of the gut, but an absence of muscular activity in the intestinal wall—i. e., intestinal paralysis. In the second the stoppage is due to actual *mechanical* closure of the lumen of the bowel from one or more of many causes.

Intestinal Paralysis.—By far the most frequent and important cause of *intestinal paralysis* is *acute peritonitis* of the infectious type, as already described under peritonitis. It was there stated that one of the most characteristic phenomena of well-developed diffuse septic peritonitis was paralysis of the gut, absence of the passage of gas and feces *per rectum*, tympanites, repeated vomiting, finally becoming stercoraceous, together with progressive symptoms of collapse continuing until death. Localized peritonitis may produce localized intestinal paresis merely, which is often recovered from, though not always. In addition to peritonitis may be mentioned violent and prolonged handling of the intestines during operations. Prolonged efforts at taxis in the reduction of large incarcerated or strangulated hernia. Evisceration and strong traction upon or operations upon the mesentery, thus paralyzing its nerves. Occasionally blows upon the abdomen with contusion of intestinal coils, marked and prolonged distention of the gut above a chronic obstruction by feces and gas; finally, as the result of embolism of the superior mesenteric artery in cases of endocarditis. We have already dwelt sufficiently upon the symptoms and diagnosis of intestinal paralysis as seen accompanying peritonitis. Under the head of differential diagnosis in acute intestinal obstruction we shall refer to it again. Embolism of the superior mesenteric artery is an invariably fatal condition, and presents a fairly typical picture; it always ends in gangrene of a large portion of the small intestine. A typical history of such a case is related by Tuholske (*Journal of the American Medical Association*, February, 1904); the important details of the case are here reproduced: A middle-aged man, who had suffered from attacks of acute articular rheumatism and had a mitral heart lesion, was suddenly seized with violent abdominal pain, most intense at the umbilicus, prostration, and vomiting. During the next two days the abdomen became distended. He continued to vomit and passed nothing *per rectum*. On the third day his condition became very grave indeed. He had a large movement from the bowels of black, tarry putrid blood. Abdomen distended, rigid, tender, frequent vomiting. Collapse threatened, clammy skin, pointed nose, sunken eyes; rapid, feeble pulse; temperature, 101° F. Incision of abdomen, foul bloody fluid escaped from peritoneum. Three feet of ileum gangrenous. Embolus in superior mesentery artery, widespread infarction of vessels of mesentery and small intestine. Death.

Mechanical Obstruction of the Bowel.—The second set of cases are due to actual mechanical obstruction of the bowel. They may be divided into two groups: (*a*) Obstruction by strangulation; (*b*) obstruction by obturation. In "A Study of One Thousand Operations for Acute Intestinal Obstruction and Gangrenous Hernia," Gibson found that thirty-five per cent of the cases were due to strangulated hernia, nineteen per cent to intussusception, a similar percentage to bands, twelve per cent to volvulus.

Group A. Strangulation.—In this group of cases not only is the lumen of the gut closed, but usually its nutrition and that of its mesentery is destroyed or endangered. To it belong all the varieties of external strangulated intestinal herniæ, except such as involve but a portion of the wall of the gut: Femoral, inguinal, umbilical, ventral, obturator, ischiadic, perineal, lumbar, vaginal. In this group, also, is included obstruction by bands. Such bands arise most commonly from adhesive peritonitis, following attacks of acute peritonitis, injuries and surgical operations upon the abdomen, notably those in which surfaces remain behind bared of peritoneum. An adherent appendix or a Meckel's diverticulum may act in the same manner. Bands may be cord-like, round, flat, or may consist of broad adhesions closely uniting broad surfaces, favoring angulation, or of firm sheets of fibrous tissue; slits in or interstices between such sheets may form orifices through which coils of gut pass and become strangulated. An adherent portion of omentum, especially if thickened by a former inflammation, may act in the same manner. Bands may act to produce strangulation in various ways. If the band is short and strong, a coil of gut slips beneath it and is compressed to the extent of strangulation. If long and free, the band may knot itself about a coil or coils. Rarely, according to Nothnagel, a coil may slip over a rigid band, and as it is filled and distended may become more or less completely strangulated by its own weight. Slits, whether merely anomalous, such as congenital orifices in the mesentery or omentum, or acquired, from ruptures of the uterus, the bladder, or even in the parietal peritoneum, may permit the passage of a coil of gut, which subsequently is pinched and strangulated. Resections of intestine, when the loss of substance in the mesentery has not been properly closed by suture, may furnish a similar opportunity. According to Schlange, slits in the broad ligament, in the suspensory ligament of the liver, have caused strangulation in the same way. Further, the various forms of internal herniæ; diaphragmatic, through the foramen of Winslow into the lesser sac; into the fossa duodeno-jejunalis (Treitz fossa); into the intersigmoid fossa, and in the pericecal peritoneal pouches.

Intestinal obstruction from strangulation is more common in the small than in the large intestine. The greater mobility of the ileum, its proximity to the various hernial orifices, its relations to the vermiform appendix and to Meckel's diverticulum; the frequency of adhesive peritonitis among its coils; the tendency of the small intestine to fall or be dragged by adhesions into the bottom of the pelvis, all favor the occurrence of strangulation. There is, how-

ever, one form of obstruction caused by rotation of intestinal coils, more common in the sigmoid flexure than elsewhere—i. e., volvulus. Of 121 cases cited by Gibson, 73 were in the colon, 58 in the sigmoid flexure, and 15 in other parts of the colon; and only 36, less than one third, were found in the small intestine.

Volvulus.—Twists may also occur in other portions of the large and small intestine, but they are less common. The *sigmoid flexure* becomes the seat of volvulus, as will be explained, as the result of congenital or acquired conditions. The rotation may occur in one of three ways (Rokitansky): (1) The bowel may make a half or a whole turn upon its own axis, and thus its lumen may be occluded. (2) More commonly, rotation of a loop occurs with the whole or a portion of its mesentery as an axis. The mesentery twists with the intestine. A rotation of from 270 to 360 degrees is necessary to produce occlusion of the gut (Lawson). Combinations of axial rotation of the gut and of rotation about the mesentery may also occur. (3) One loop of intestine may form a band about which another loop rotates, thus forming in some cases a knot or knots. The sigmoid with a long mesentery and a loop of ileum are commonly associated in this condition. Predisposing causes of volvulus are a sigmoid having a long narrow mesentery; as stated, this may be a congenital anomaly. In other cases it appears to be an acquired condition due to improper feeding during childhood and chronic constipation; the sigmoid may thus be dilated and unduly long; though the volvulus is more apt to occur during the later years of life. According to Fitz, in 34 cases the largest number in any decade was between the thirtieth and fortieth year. In 121 cases collected by Gibson, the average age was forty-five years. As the result of chronic constipation the sigmoid is often distended, its mesentery lengthened and narrowed by traction. If, now, on some particular occasion, the upper loop is distended with accumulated feces, a sudden jar of the body, a violent muscular effort, or pressure upon the abdomen, may be sufficient to cause the upper loop to fall downward over the lower loop. The rotation is thus started; further distention of the twisted gut serves to render the twist more complete and incapable of spontaneous reduction; complete strangulation of bowel and mesentery follows. As already stated, such distention may be extreme. Volvulus of other portions of the colon occur more rarely, and are favored by a long mesentery. Thus volvulus of the splenic and hepatic flexures have been observed as great rarities. As stated, the transverse colon may hang down in a long, sharp loop to the pubes, and may be the seat of volvulus. Volvulus of the small intestine is favored by a short, narrow mesenteric attachment and a long mesentery. As an extreme case favoring such an occurrence, the congenital abnormality illustrated in Fig. 21 will serve as an example. Local pathological conditions may also predispose to volvulus of the small gut. A coil of ileum long prolapsed in a hernial sac may have its mesentery unduly narrowed and lengthened. Cicatricial contraction of the mesentery from former attacks of peritonitis predisposes to volvulus in a similar manner. I operated upon a child, aged seven years, for a volvulus of the small intestine, which occurred as the

result of a violent push from behind. The ileum had a congenitally short mesenteric attachment, while the mesentery itself was unusually long. A single coil of ileum about eighteen inches in length was twisted one and a half times round, including its mesentery, and was gangrenous. The gangrenous coil was resected, but the twist in the mesentery had so far interfered with the circulation of the entire small intestine that the gangrene spread widely above and below the resected portion, and the child died with more than half his small intestine necrotic. Volvulus of the small intestine is, as stated, often associated with and caused by hernia; the two may coexist. It is well for the surgeon to bear in mind when operating upon an irreducible hernia in the presence of symptoms of intestinal obstruction that, failing to find the gut in the hernial sac strangulated, a volvulus may be causing the obstruction. Vaughan in 1903 ("Volvulus of the Small Intestine," etc., *American Journal of the Medical Sciences*, May, 1903) published records of collected cases, including his own. He collected 61 cases. Of them, 21 involved torsion of the entire mesentery; 40 were partial only, a portion of the mesentery and small intestine being involved in the twist.

Angulation.—A further group of cases of acute obstruction are those caused by angulation of loops of bowel. They are, as stated, frequently caused by bands and adhesions. Very striking examples of angulation are the cases of obstruction of the duodenum, or of a pylorus fixed by adhesions, from the sagging of a dilated stomach. I operated on a case a few years ago of a peculiar character. A middle-aged woman of a highly neurotic temperament suffered from attacks of abdominal pain, with obstinate constipation, accompanied sometimes by vomiting. During the attacks her abdomen became somewhat distended and tender in the lower half. Upon opening her abdomen an unusually long sigmoid loop was found; the apex of the loop was firmly adherent to the abdominal wall at the brim of the pelvis upon the left side in front, over an area circular in shape and an inch in diameter. A marked angulation of the gut had been produced at this point, although not total occlusion of the bowel. The bowel was freed, when it was found that an ulcerative process had slowly perforated at this point and had grown firmly adherent. There was no evidence of extensive old adhesions throughout the belly. The borders of the ulcerated area were inverted with sutures; the symptoms were relieved, but the patient remains as neurasthenic as before.

Group B. Obstruction by Obturation.—The lumen of the intestine may be closed by causes acting from within the gut itself. Thus, tumors and cicatrices causing strictures, rarely by a tumor acting as a ball valve; further, by foreign bodies, whether swallowed or formed within the body, such as enteroliths, gall-stones, fecal impactions. Intussusception may also be included, although here the phenomena partake also of the character of strangulation.

Causes acting from without are the pressure of tumors or exudates pressing upon, and thus closing, the lumen of the gut. Among tumors of the intestine causing obturation carcinoma is the most frequent. It involves

usually the large intestine, more commonly the rectum than any other part. In many cases the tumor is small, and forms a narrow constricting ring about the gut. In others a massive palpable growth may be present. In these cases the symptoms of chronic obstruction are apt to precede the total occlusion. The sarcomata of the intestine, although they form massive tumors, rarely cause total occlusion and acute obstruction. Among ulcerative processes leading to cicatricial contraction tuberculosis and syphilis are the most common. The former affects chiefly the small intestine, the latter the rectum, although other portions of the colon may be involved. Dysenteric ulceration of the colon may lead to obstruction, although this result is believed to be rare, as is also true in those cases of ulceration of the bowel due to pressure necrosis of the mucous membrane from impacted feces. Treves described several cases of obstruction of the small gut following the reduction of strangulated herniæ. The pressure of the constricting ring had caused necrosis of the mucous membrane of the bowel and circular cicatricial contraction. Any large intra-abdominal tumor may cause partial or even complete occlusion of the bowel by pressure. Severe constipation, colicky pain, and other digestive disturbances are common under such conditions; actual complete occlusion is rare. *Obturation by foreign bodies occurs.* Such may be bodies swallowed; their behavior in the intestine has already been sufficiently described. *Gall-stones* large enough to obstruct the bowel nearly always gain access to the gut by ulceration through the gall-bladder. A very few cases have been observed where the stone entered through a dilated common duct. They may, as already stated under Foreign Bodies, cause obstruction by producing spasm of the wall of the gut, which clasps them tightly. The obstruction is in the small intestine. I had a fatal case of this kind in January, 1909, mentioned under Foreign Bodies in the Intestine. *Enteroliths* are formed nearly always in the large intestine by slow accretions of earthy salts (the alkaline earths) about a nucleus which may be organic or inorganic. In the same general category belong hair balls and masses of vegetable fiber. The unusual case observed by Dr. Hodenpyl of a man who swallowed half a dried peach, which lodged in the ileum a foot above the cecum, and caused death, has been noted elsewhere, as well as a case in which a knotted mass of intestinal worms occluded the ileo-cecal valve. Fecal impaction may give rise to occlusion of the gut. In cases of old people whose large intestines are atonic, such may occur without any stricture of the gut. In the presence of a congenital or acquired stricture a much smaller fecal mass may be sufficient to occlude the bowel.

Intussusception—Invagination of the Bowel.—Where one portion of the intestine penetrates into the lumen of the next adjoining portion the condition is known as intussusception. The part penetrating the other is known as the intussusceptum, and consists of two layers. The penetrated or outer part, the sheath, in fact, is known as the intussuscipiens. Between the innermost and middle layer lies that portion of the mesentery which has been drawn into the tumor. "This portion of mesentery, which is folded up into a cone-shaped

mass, pulls upon the lower border of the intussusceptum, and throws it into a curve, the concavity of which is directed toward the mesenteric portion of the intestine. The inner orifice of the intussusceptum, which was originally circular, is drawn into an elongated slit by the traction thus exerted" (Warren, "International Text-book of Surgery").[1] It occasionally happens in the large intestine (transverse colon and sigmoid flexure) that the process of invagination comes to an end in one section of the bowel, and that the entire intussusception becomes invaginated into a lower loop. In rare cases the process may be once more repeated. (For the theories of the mechanism and causation of the disease the reader is referred to large works and monographs.)

Varieties.—Invagination may take place in any part of the alimentary canal. There are, however, seats of predilection. The commonest form is where the ileum enters the cecum at the ileo-cecal valve. Leichtenstern places it at 52 per cent of all cases, and during the first year of life at 70 per cent of all cases. Wiggin found this variety to have existed in 89 per cent of 103 cases. The next most frequent form is the enteric, small intestine into small intestine, 30 per cent (Leichtenstern). The colic, 18 per cent. In the ileocolic form the ileo-cecal orifice forms the apex of the intussusceptum, and may traverse the entire length of the large intestine and appear at the anus.

Causation.—A certain degree of atony of one portion of gut and an active peristalsis on the part of another are necessary for the production of intussusception. Such conditions may be produced by trauma, such as violent shaking, a blow upon the abdomen, distention of the bowel from overeating and drinking. In many cases severe constipation has preceded. Some cases have been observed caused by peristaltic action on a pedunculated growth of the intestinal wall, the pedicle dragging the wall of the gut after itself, thus causing its invagination. In very rare cases the invagination of a Meckel's diverticulum has started the intussusception (Cheyne, Heller, *Annals of Surgery*, December, 1904). Age exercises a most important influence. The disease occurs most often during the first year of life, and is three times more frequent in males than in females. In infants intussusception usually occurs without any apparent cause in well-nourished healthy babies.

Course of the Disease.—The disease may be described as running its course in an acute or chronic form. When invagination is established a more or less profound disturbance of circulation takes place in the intussusceptum from pressure on its mesentery, the gut swells, becomes edematous, hemorrhages take place into its substance and often into the lumen of the bowel. In the worst cases the gut becomes gangrenous, and may be discharged *per rectum* as a slough or sloughs from an inch to a yard or more in length, should the patient survive. Such sloughs usually come away between the eleventh and twenty-first day of the disease, in other cases much later. In operated cases gangrene of the gut has been observed twenty-eight hours after the first symptoms

[1] Vol. ii, page 353. W. B. Saunders Co.

appeared. In less severe cases the circulatory equilibrium may be reëstablished more or less perfectly, and the lumen of the bowel may become sufficiently patent to permit the passage of feces. The patient is still exposed to danger from perforation at the constricted neck of the invagination and death from peritonitis. In other cases the patient lives long enough to die of sepsis and exhaustion, perhaps after months. In still others, after separation of the sloughs, stricture of the bowel occurs at the lines of separation at a later period. Such a case occurred recently in my service at the New York Hospital. It was operated upon by my associate, Dr. William A. Downes. The patient was a man thirty-five years old, who after an attack of intussusception thirty-one years before had discharged a large portion of small intestine *per anum*. The obstruction of the bowel occurred at the site of the separation by cicatricial stenosis, and elsewhere by bands. Paralysis of the gut was absolute, and the patient was not benefited by a lateral anastomosis. Cure or partial cure by sloughing and spontaneous evacuation are more common in intussusception of the small intestine than of the large. The most acute cases occur in young infants during the first year of life. The symptoms of intussusception differ from ordinary acute intestinal obstruction, and are characteristic in most cases, so that I shall mention them before discussing the diagnosis of acute obstruction in general. The duration of the acute cases is from twenty-four hours to two weeks. In the most severe types an infant is seized with sudden severe abdominal pain, rapidly passes into a condition of collapse with vomiting and a subnormal temperature, and dies. The characteristic signs of the disease may or may not develop. In ordinary cases the disease lasts one or two weeks before the fatal issue, unless relieved by operation. The patient, infant or adult, but usually a baby with a previous history of good health, is seized with very severe cramplike pain in the abdomen, sometimes general, sometimes referred to the umbilicus. The pain lasts an hour or several hours, and subsides, to be renewed after a longer or shorter interval. Accompanying the pain there is usually vomiting. Late in the disease the vomiting may become stercoraceous. Such is not, however, the rule. The patients are also affected at once with diarrhea, the normal contents of the bowel are first expelled, followed within the first twenty-four hours by the passage of *mucus mixed with blood*, the characteristic diarrhea of intussusception. With the diarrhea there is a more or less constant desire to stool and painful straining. The bloody mucus somewhat resembles currant jelly in appearance. It may appear alone or mixed with more or less fecal matter, according to whether the bowel is pervious or not, and to whether the intestine above is paralyzed or not.

During the earlier period of the disease the abdomen is not distended, and is not notably tender or rigid, except during the paroxysms of pain. At a later period the signs of peritonitis may obscure the picture, but often in adults, and usually in infants, palpation of the abdomen permits the recognition of the *characteristic sausage-shaped tumor composed of the invaginated coils*. Such a tumor can usually be detected when the colon or colon and ileum are

involved. When the small intestine alone is the seat it will be absent or hard to detect. A tumor is to be felt in children in a very large proportion of cases. Thus, C. H. Fagge (*Annals of Surgery*, March, 1905) was able to feel a tumor in sixteen out of eighteen cases seen. When felt it will be cylindrical or sausage-shaped. It may be found in the right iliac fossa or anywhere along the course of the colon, or in any indifferent position in the lower half of the abdomen. The tumor is firm, not tender, usually freely movable, and may change its position from time to time spontaneously. Rectal examination may detect its apex in the rectum, or it may even protrude through the anus. When no tumor is felt by abdominal examination alone, combined rectal and abdominal examination may detect it. In cases of doubt, examination under an anesthetic is desirable, to be followed at once by operation if a tumor is felt. Indeed, we must depend for a diagnosis very largely on the presence of a palpable mass. Errors may, of course, occur. A mass of glands in the right iliac fossa has been mistaken for an intussusception, and in a chronic case an intussusception has been mistaken for a hardened and contracted omentum, and the case diagnosticated as one of tuberculous peritonitis (Cuthbert Wallace, *Annals of Surgery*, March, 1905). Blood may be found in the stools of infants suffering from acute enteritis or from polypoid growths of the rectum. But the history of a sudden violent attack of pain and the presence of a tumor are absent. The treatment of intussusception is now regarded by most surgeons as purely operative, and that at the earliest possible moment. Spontaneous reduction is probably rare, and the proportion of cases saved by enemata or inflation of the bowel is small. Adhesions between the invaginated coils occur after a variable time, and may render reduction difficult or impossible. Such adhesions may, however, be absent for several days after the beginning of the attack. Gibson (*Annals of Surgery*, 1900) states that on the first day of the disease 94 per cent are reducible; on the second day, 83 per cent; on the third day, 61 per cent. All observers are agreed that the very high mortality of intussusception has been materially reduced by early operation, practiced as a routine measure. There is nothing characteristic about the pulse and temperature. In the very bad cases the pulse will be that of shock from the start, feeble, compressible, and rapid. In less severe cases the pulse will gradually grow more rapid and feeble until death. The temperature in acute cases is normal or subnormal. If the patient survives or develops complications, perforation, peritonitis, septic infection of the mesenteric veins, and pyemia, etc., there will be a rise of temperature of a kind more or less characteristic. In the chronic cases the disease begins as in the acute forms, but the constitutional depression is less severe, the bowels are not entirely obstructed, or if at first obstructed the swelling of the gut diminishes, and diarrhea ensues. In these cases, as already indicated, when untreated, sloughing of the bowel and its passage *per rectum* is the most favorable outcome, and is often followed by stricture. The patients may live for months, to die of exhaustion, sepsis, intoxication from decomposing intestinal contents, peritonitis, or other complication.

Symptoms and Diagnosis of Acute Intestinal Obstruction.—The diagnosis of acute obstruction of the bowels after the symptoms are well developed presents no difficulties whatever. The cardinal signs and symptoms are: *Abdominal pain* and *vomiting*, first of the contents of the stomach, then of bile-stained fluid, assuming after hours or days a fecal character. As has already been indicated in several places in this book, so-called fecal or stercoraceous vomiting does not indicate that the contents of the large intestine have reached the stomach by reversed peristalsis and are then vomited. Such an event occurs only when a fistulous opening exists between the stomach and the colon, and rarely then. Fecal vomiting, as ordinarily seen, means simply that the contents of the small gut, stagnating and putrefying above an obstruction or in paralyzed bowel, regurgitate by mechanical overflow into the stomach, and are vomited. The fecal character of the vomited material gives no clew to the situation of the obstruction. The time of its occurrence, on the other hand, may be an aid in diagnosis. In partial obstructions it is usually absent or occurs later in the disease. In obstruction of the large intestine it occurs late or may be absent. In general peritonitis with paralysis of the bowel it usually occurs soon after paresis of the gut is established. When the obstruction is rather high in the small intestine it is apt to occur very early. *Distention* of the bowel and abdomen with gas accumulated in the intestine above the point of obstruction from fermentative and putrefactive changes in its contents. *Absolute constipation*, the bowel once emptied, no further escape of gas or feces occurs *per anum*. *Prostration*, coming on suddenly under the guise of *shock* or slowly after hours, in either case progressive, ending in the death of the individual in collapse after a period of one or several days. In addition to these essential symptoms there will be progressive enfeeblement of the action of the heart; in some cases a rise of temperature; in others, none; in still others, the temperature will be subnormal, according to varying conditions.

The quantity of *urine* passed is regularly diminished, partly on account of the loss of fluid by vomiting, partly from inability on the part of the intestine to absorb fluid, and partly, in the later stages of the disease, from diminished arterial blood-pressure. *Indican* is present in the urine in cases of diffuse peritonitis in large quantities. In obstruction of the ileum it is usually present in increased quantities after the first twenty-four hours. In obstruction of the large intestine, it may be absent or but slightly increased. Its presence depends upon the absorption of the putrid decomposition products of albumin, chiefly from the small intestine. The various signs and symptoms present an urgent clinical picture, which, taken together with the pale, pinched, anxious features, sunken eyes, clammy skin, cool and often cyanotic extremities, are readily enough recognized. The picture will, however, vary a good deal in different cases, according to the cause and seat of the obstruction. From the point of view of operative treatment, it is desirable for the surgeon to know the seat and character of the obstruction, in order that the lesion may be approached certainly and without loss of time after opening the abdomen.

Rapid work is usually a very important element in the success of operations of this character, done usually upon patients already weak and exhausted. In a certain proportion of cases the operator may, from the history of the case and from the examination of the abdomen, make a fairly accurate anatomical diagnosis; in some he may be able to exclude certain conditions and not others; in other cases, notably when first seen late in the disease, and with an imperfect history, the diagnosis of obstruction will be plain, but its cause will remain quite unknown until the abdomen is opened. A knowledge of the local effects upon the intestine and the behavior of the gut in the different forms of intestinal obstruction sometimes is a valuable aid in differentiating the several types of the disease.

Differential Diagnosis of Acute Intestinal Obstruction.—PERITONITIS.—As it has already been stated, localized peritonitis exercises a paralyzing effect upon the inflamed coils of gut, still the paralysis is rarely absolute. Gas is still able to pass into noninflamed coils. Tympanites is not noticeable or is slight. The symptoms of obstruction do not appear from this cause alone. Diffuse purulent peritonitis, on the other hand, whether of the purulent, fibrino-purulent, or putrid type, produces, unless the patient dies of sepsis very early in the disease, total paralysis of the intestine, the abdomen is uniformly and markedly distended, peristaltic movements cease. In cases of *strangulation* of the gut, the strangulated loop is rapidly distended with putrefactive gases in a few hours, and remains anchored at one place in the belly. No peristaltic movements occur in the strangulated loop. The distention of the strangulated portion may be very great, and if a large portion of intestine is involved may fill almost the entire belly. Such great distention of the strangulated coil is commonly seen in cases of volvulus of a long sigmoid. In such cases a sero-sanguinolent and often an infected evil-smelling transudate in considerable amount may accumulate rapidly in the peritoneum, giving the signs of dullness in the flanks even during the first day. The transudation is identical with that observed in cases of strangulated external herniæ. The lower efferent portion of the bowel empties itself, and remains empty. The behavior of the afferent coils varies. If the length of strangulated gut be great, no noticeable distention may be observed in these coils at the time of operation. These cases run their course rapidly, and die with the symptoms of shock followed by collapse, if not relieved very early by operation. If only a small loop of gut be involved the symptoms of shock are not marked, the patient may live for a number of days, and the afferent portion of the intestine has time to become distended. According to Schlange, under favorable conditions, increased peristaltic movements and rigidity of the bowel can sometimes be appreciated in these distended coils, as in cases of chronic obstruction of the small gut, already described, but in a far less marked degree. Whether separate coils are recognizable or not, gradual progressive distention of the bowel above the obstruction regularly occurs, and leads before death to a marked degree of tympanites. When gangrene of the gut occurs, so that

it becomes pervious to bacteria or actual perforation takes place, the signs and symptoms of diffuse peritonitis entirely obscure these local signs. In cases of *obturation* the gut above the obstruction gradually distends a variable distance toward the stomach. The afferent coils show increased peristaltic activity. If the obturation is incomplete or is slowly developed, as from a carcinomatous or other stricture, the clinical picture gradually merges into that of chronic obstruction, as already described. Perhaps the most important, certainly the first, question the surgeon must ask himself when confronted by a case presenting the symptoms of intestinal obstruction is: Are the symptoms due to paralysis of the gut from peritonitis or to actual mechanical obstruction of the bowel? While it is true that both conditions may be present, in the former class of cases the peritonitis will have ushered in the disease; the symptoms of obstruction are but the last stage of the picture. In the latter the obstructive symptoms will have appeared first, the peritonitis is a secondary lesion, and merely closes the scene. The signs and symptoms of well-developed diffuse peritonitis have been dwelt upon at length under Peritonitis. Briefly recapitulated they are: a pale, pinched, and sunken countenance; hollow eyes; an anxious expression; a uniformly and markedly distended abdomen, with no individual intestinal coils visible upon its surface; the knees and thighs often flexed; thirst; diminished urinary secretions; repeated vomiting, becoming fecal; restlessness; severe, continuous abdominal pain; general abdominal rigidity and tenderness; hurried breathing of the costal type; dyspnea; a rapid, feeble, and compressible pulse. Fever may be present or absent. It is usually present in diffuse purulent peritonitis, although its height is no criterion of the severity of the disease. When present it bespeaks peritonitis rather than an uncomplicated mechanical obstruction. (For the value of the blood count in diagnosis, see section on the Blood.) Here the history of the case is often of great assistance. A history of an attack of abdominal pain, localized after some hours in the right iliac fossa, perhaps of several such attacks, points inevitably to appendicitis. A history of chronic gastric disturbances, to ulcer of the stomach or duodenum. A history of jaundice and of pain in the region of the gall-bladder, to gall-stone disease and perforation. A history of continued fever for days or weeks, with diarrhea and prostration, to perforation of a typhoid ulcer. A history of menstrual disturbances, of attacks of pelvic pain, of endometritis, to pelvic peritonitis, often gonorrheal. It is generally stated that peritonitis arising from the tubes and ovaries very rarely runs a stormy course. The following brief abstract of a case I operated upon a few years ago illustrates that it sometimes does, and that one cannot be too thorough in examining cases of apparent intestinal obstruction. I insert it because it taught me a lesson I ought to have learned long before:

A woman was admitted to the Hudson Street Hospital with the following history: She had been operated upon in that hospital a year before for peritonitis; the incision had been made in the middle line above the pubes. The origin of the

peritonitis was a perforated appendix; this had been removed. On the day before I saw her she had fallen downstairs, and had at once been seized with severe abdominal pain, vomiting, and prostration, followed in a few hours by abdominal distention. When I saw her at the hospital, the following afternoon, the vomiting had continued and become bile-stained, though not foul. She looked seriously ill and complained of severe abdominal pain, localized in the lower half of the abdomen. Temperature 99° F. Pulse 110. No blood count was made. The lower half of the rather thin, flabby abdomen was notably distended; beneath the thinned-out scar in the middle line could be seen several distended coils of small intestine; abdominal tenderness and rigidity not marked; the distended coils felt soft; no peristaltic movements were heard or felt in them. Diagnosis, intestinal obstruction in the ileum, probably the result of a band which had engaged a coil of gut as the result of the fall of the day before. The former attack of peritonitis abundantly accounted for the presence of bands and adhesions. No vaginal examination made. Abdomen opened in the middle line. Purulent fluid escaped at once in large amount; the pus had a fecal odor. Small intestines distended and everywhere reddened and covered with flakes of fibrin. The peritonitis seemed most intense among the coils of ileum. Appendical region, appendix absent, otherwise normal. There were no bands nor adhesions anywhere. When finally I explored the pelvis the diagnosis became quite clear. I found double pus tubes; upon the left side a large tubo-ovarian abscess, which had been ruptured the day before by the fall and had caused the peritonitis. Cultures from the pus showed colon bacillus. The woman recovered; but had a vaginal examination been made, the error in diagnosis would hardly have occurred.

In the absence of any definite history, but with the signs of peritonitis well marked, the surgeon will sometimes remain in doubt as to the origin of the trouble. The question of operative interference will depend upon the general condition of the individual. Whether originating as an infection of the peritoneum, or as a mechanical closure of the gut with secondary peritonitis, it is, of course, useless to attempt an extensive and radical operation upon a dying patient. When cyanosis of the face and trunk are noted, when mental dullness and apathy are marked, when the pulse is 140 to 150 or more, and flickering, when complete paralysis of the intestine is evident, it is useless to operate. In other cases less desperate, operation may be attempted. Very rarely does a palliative operation, such as the formation of an artificial anus, do any good in the small gut. In the large intestine, if gangrene has not occurred, it may be the means of saving life. The decision for or against operation must depend upon the individual skill and judgment of the surgeon. When surrounded by all the aids and the trained assistants, such as a well-equipped hospital ought to furnish; where the work can be done rapidly, and where the operator is accustomed to such work, operations may properly be undertaken that would be unjustifiable under less favorable surroundings, notably if the operator is without considerable experience in surgery of this kind.

Mechanical Obstruction.—Assuming that peritonitis or other cause of paralysis of the gut has been excluded, we shall next consider cases of mechan

ical obstruction. The signs and symptoms differ to some extent in cases of strangulation from those observed in obturation. Combination forms also occur, as described under Intussusception. Typical cases of *strangulation of the bowel* exhibit the following train of symptoms: An individual is suddenly seized with pain in the abdomen, and becomes violently ill at once. The pain is very severe. Much more severe when the small intestine is strangulated than when the colon alone is involved. The situation of the pain is rarely of much diagnostic value. It is referred usually to the umbilical region, or is a generalized pain; it may be largely referred to the back. It is a continuous pain, and thus differs from colic and from the intermittent pain of intussusception. Accompanying the pain, or soon after its onset, the patient vomits first the contents of the stomach; as the hours go by the vomiting is repeated at intervals, becoming first bile-stained, later foul and stercoraceous. In volvulus of the sigmoid, vomiting may be delayed or absent. Along with vomiting, painful, frequent hiccough is a common symptom. Very often the onset of strangulation is accompanied by a desire to defecate. The bowel below the obstruction empties itself; after that neither gas nor feces pass. If the strangulation is complete, and especially if a large portion of intestine is involved, the patient falls almost immediately into a condition of shock, and this may be followed after twelve to twenty-four or more hours by collapse, indicating that the gut has become gangrenous, or at least that its vitality is so far impaired as to permit the passage of bacteria and consequent septic or putrid absorption from the peritoneum. The time when this occurs varies according to the completeness of the strangulation; it may be postponed for several days. As a matter of practical experience, it is found that operations done on these cases after the second day are far more rarely successful than those done during the first forty-eight hours. The general appearance of the individual, the pulse, the oliguria, etc., of acute obstruction have already been mentioned. Fever is usually absent. Inspection of the abdomen some hours or a day after the onset of the symptoms always shows distention, unless the obstruction is high up in the small intestine. If the abdominal wall is thick, we cannot make out any definite outline of the strangulated bowel. If thin and flabby, a localized meteorism of more or less characteristic size and shape may be visible. Localized tympany in the left lower quadrant of the belly, spreading upward and to the right, finally becoming general, suggests volvulus of the sigmoid flexure. Palpation, before the onset of peritonitis, shows absence of the marked rigidity and tenderness characteristic of inflammation of the peritoneum. Neither palpation, percussion, nor auscultation will reveal peristaltic movements in the strangulated coils, if such be visible. If the length of the strangulated bowel is considerable, the picture will simply be that of general tympanites, and the same will be true in any case if the patient is not seen until the second or third day, when the afferent bowel has become markedly distended. As part of his examination the surgeon will inspect all the seats of external hernia. Rectal palpation in both sexes and vaginal palpation in the female should not

be omitted. If a large portion of gut is strangulated, dullness in the flanks, indicating free fluid, may sometimes be detected on the second day. In seeking to determine the situation of the obstruction injection of water into the rectum is sometimes valuable. If able to inject several quarts of water into the bowel by very gentle hydrostatic pressure, we exclude volvulus of the sigmoid. The obstruction is probably in the small intestine, or at least above the sigmoid. When the sigmoid is the seat of volvulus, one quart of water is the limit of distensibility of the gut below. Inability to inject that quantity, or even a pint, does not prove that the obstruction is near the anus, unless the injection is made under a general anesthetic, since an uncontrollable desire to expel even small quantities of water introduced into the rectum is frequently present in any case of acute obstruction. As already indicated, the progress of acute obstruction from strangulation is always to a fatal issue. The fecal vomiting continues. The belly becomes more and more distended, the patient more and more exhausted. Gangrene or perforation of gut causes peritoneal sepsis and death in collapse. If the circulation of the constricted bowel is not completely shut off, or if, as sometimes happens in obstruction by bands, the lumen of the gut is not completely closed at first, the symptoms may be less acute. (See case of obstruction by bands already related.) The patient will have abdominal pain and will vomit. The vomit will not be foul perhaps for many days. Distention will develop slowly and progressively, and will represent the afferent bowel. Peristaltic sounds, and even palpable movements, may be detected over these coils for days before they become paralyzed, as the result of complete occlusion. The patient may continue to pass gas and a little feces from time to time. In these cases a previous history of an abdominal operation, or of attacks of localized peritonitis, usually appendical or pelvic, may greatly aid the surgeon to decide upon early operation. (See Differential Diagnosis in following paragraphs.)

Obstruction by Obturation.—The symptoms of obstruction by obturation can in many instances be distinguished from those of strangulation. The sudden violent onset of severe abdominal pain, followed at once by the symptoms of shock characteristic of strangulation, are absent. In strangulation the pain is severe and continuous from the start; in obturation it is severe, but intermittent and paroxysmal, and is accompanied by forceful contractions of the afferent bowel in the effort to overcome the obstruction. Vomiting is, with few exceptions, a symptom accompanying the initial pain and shock of strangulation. Vomiting in obturation is regularly developed after a certain time, and is due to accumulation of intestinal contents above the obstructed point and regurgitation into the stomach, but it is rarely one of the initial symptoms of the disease. In the later stages it regularly becomes fecal. The obstruction in strangulation is usually, though, as already indicated, not always, complete at once. In obturation such is less often the case, so that feces and gas may continue to be passed in small quantities for many days before the bowel is entirely occluded. The patients may thus continue to suffer from moderate

symptoms of obstruction for some time before the strength fails utterly; the pulse may thus long remain of good quality. Evidences of increased peristalsis in the coils of small intestine can often be made out, as described under chronic obstruction. In a certain proportion of cases there will be a history of a foreign body swallowed. In others, notably in elderly persons, a history of gall-stone disease with or without jaundice. Gall-stones are a more frequent cause of obstruction than enteroliths, the latter being very rare. The patients are oftener women than men, between the ages of fifty and seventy years. During the time when the stone is ulcerating through the gall-bladder into the duodenum the patient will usually suffer from a good deal of pain and the signs of local peritonitis. This may be followed by the appearance of tarry blood in the stools. The obstruction is rarely absolute at first; the symptoms are those of irritation of the bowel and partial obstruction. The stone stops in the lower part of the ileum or at the ileo-cecal valve oftener than elsewhere. It may stop in the duodenum or jejunum. Irritation of the bowel and firm spasm of its muscular coat holds the stone in its position; ulceration of the mucous membrane of the gut is common, sometimes localized peritonitis; perforation is rare. Very rarely the stone has been felt through the abdominal wall. There is nothing about the symptoms of acute obstruction caused by enteroliths or gall-stones to distinguish them from other forms of acute obturation, as described. In a certain proportion of cases, probably half, spontaneous cure results by the final passage of the stone. In 149 cases collected by Lothrop, the mortality of the nonoperated cases was 63 per cent; in the operated cases, 23 in number, 52 per cent. Obturation of the bowel by tumors other than carcinoma is rare. As stated, carcinoma of the cecum usually produces a tumor of considerable size. The same may be true in other portions of the gut, but very often the cancer forms only a small constricting ring and remains impalpable. At the time when we see these cases, the obstruction being of a chronic character, ending finally with acute symptoms, the afferent gut is so enlarged and distended that the small tumor, perhaps no larger than the last joint of one's thumb, as I have observed in several cases, is entirely beyond the reach of palpation. Acute obturation caused by tumors is usually due to benign growths, polypoid or pedunculated in shape, projecting into the lumen of the gut—lipoma, fibroma, myoma. They may be tightly clasped by the muscular wall of the bowel, or cause invagination, or be the cause of fecal impaction. In other cases a palpable tumor may be felt in the right iliac fossa, a carcinoma or tuberculous disease of the cecum. In others bimanual examination will reveal a pelvic tumor, uterine or ovarian, or growing from the pelvis or from retroperitoneal structures. Rectal examination will reveal a carcinoma or stricture of the rectum, if such be present. As in strangulation, injection of water into the rectum may immediately disclose that the obstruction is or is not above the sigmoid. (See also Inflation of the Bowel with Air.) The history of progressive constipation or of constipation alternating with diarrhea in an elderly person, together with a mucous discharge

tinged with blood from the bowel, will suggest carcinoma somewhere in the colon. A history of chronic constipation and the presence of scybalous masses in the rectum or of a doughy tumor in the course of the colon or in the cecum indicates fecal impaction.

Some General Remarks on Diagnosis in Mechanical Obstruction.—Infants and children with intestinal obstruction are usually suffering from intussusception with its tumor and bloody stools. In subacute and chronic cases from tuberculous peritonitis. Volvulus of the sigmoid affects adults, usually between forty and sixty years of age. There is a history of chronic constipation. The cases number four men to one woman. The onset is less violent than in strangulation of the ileum, and shock and early collapse less marked. Vomiting is often delayed or absent. Rectal tenesmus is common, blood is rarely passed *per rectum*. The distention begins in the left lower quadrant of the belly. Strangulation by bands is rare in childhood, very common in early adult life; in more than half the cases a history of peritonitis has preceded the attack, and the ileum is the commonest site. The appendix, or Meckel's diverticulum, may act as a band in these cases. A pretty large proportion of cases of obstruction by strangulation are due to postoperative adhesions, and the obstruction may follow the operation in a few days or after a long interval. In the cases immediately following operation, the occlusion is, in my experience, due to a kink or angulation of the gut more often than to actual strangulation. The onset of an attack of strangulation of the ileum is sudden and violent, as described. Rectal tenesmus is usually absent. Vomiting occurs early.

Internal Herniæ as a Cause of Obstruction.—The various forms of internal herniæ are rare causes of obstruction, and I find no record of cases diagnosticated as such before operation. They are divided into:

1. Retroperitoneal herniæ, occurring in three situations: (*a*) Hernia in the fossa duodeno-jejunalis or fossa of Treitz; (*b*) intersigmoid hernia; (*c*) pericecal hernia.
2. Properitoneal hernia.
3. Hernia through the foramen of Winslow—i. e., into the lesser sac.
4. Diaphragmatic hernia.

Of these herniæ, duodeno-jejunalis is the most common. The fossa is thus described by Warren ("International Text-book," vol. ii, page 348):

> The point of origin of this hernia is the fossa duodeno-jejunalis, which is formed beneath a fold of peritoneum at the point of junction of the jejunum and the duodenum. This fossa can be exposed on the cadaver by throwing up the omentum and transverse colon and pressing the mass of small intestine to the right. In well-marked cases it is found lying to the left of the third lumbar vertebra, with its opening looking upward and inward. The margin of this opening is formed by a fold of peritoneum near the point where the duodenum emerges from its retroperitoneal position to receive a mesenteric attachment. In the lower border of this fold lies the inferior mesenteric vein, and also the colica sinistra, a

branch of the inferior mesenteric artery. The fossa contains more or less of the angle of the bowel, and sometimes the whole of the loop.

When intestinal coils enter this pouch, they raise up the posterior layer of peritoneum, passing to the right, sometimes behind the parietal peritoneum, sometimes separating the layers of the mesocolon, so that these peritoneal layers become a part of the wall of the sac. All the small intestine may pass behind the peritoneum in this way, so that upon opening the abdomen they are entirely concealed. The stomach and colon alone are visible. The opening of the sac being directed to the right, the tumor, composed of small intestine, usually forms to the left of the median line. Although the condition is not exceedingly rare, strangulation has occurred in only a few cases. Leichtenstern, who has investigated and written upon the subject, says with reference to diagnosis as quoted by Tuholske:

I consider probable diagnosis possible under favorable circumstances and with a fairly large hernia. The circumscribed, spherical distention of the mesogastrium; collapse or sinking of the territory occupied by the colon; the palpability of a circumscribed, tense, elastic, spherical mass, which gives the impression of a large, somewhat movable cyst, which tends toward the left from the mesogastrium; the quality of a definable tumor which gives a sonorous percussion sound, and on auscultation loud, clear, intestinal noises, with bleeding from the rectum and hemorrhoids, from compression of the inferior mesenteric veins, seem to make a fairly clear picture.

Pericecal Hernia.—Three fossæ may exist in the peritoneum about the cecum. A superior and inferior ileo-cecal and a subcecal. A few cases of hernia into these fossæ have been collected and reported by Manski. They were twelve in number. Eight were male adults, one an infant. The herniæ varied in size from a single loop of ileum to a large part of the small intestine. The symptoms of intestinal obstruction developed in a certain number of these cases.

Intersigmoid Hernia.—The intersigmoid fossa is a physiological recess in the peritoneum, formed along the line of attachment of the left leaf of the sigmoid mesocolon. It is seldom seen in adults. One border of the recess is outlined by the sigmoid artery. Hernia into this recess has been observed as a very great rarity.

Hernia through the Foramen of Winslow.—Hernia through the foramen of Winslow, or more correctly prolapse of the intestines through the foramen into the bursa omentalis or lesser sac, has been observed as a cause of acute obstruction. The symptoms have been sudden pain and the formation of a tumor in the epigastrium, together with other symptoms of acute obstruction. When not strangulated, gurgling in the tumor and a change in its size from time to time, according to its content of gas, etc., have been observed.

Diaphragmatic Hernia.—Diaphragmatic hernia has been spoken of under Diaphragm.

Properitoneal and Interstitial Herniæ.—(See Hernia.)

ULCERATIVE PROCESSES OF THE INTESTINE

Aside from the peptic ulcers of the stomach and duodenum, a great variety of conditions may give rise to ulceration of the wall of the gut. Some of them are due to local, others to constitutional conditions. Many of them are not in any way amenable to surgical treatment. A few only may cause either perforation or stricture of the gut, or the formation of a tumor, and come into the surgeon's hands. Of these, by far the most frequent and important is typhoid perforation of the intestine, and less commonly, as a cause of perforation, tuberculous ulceration of the solitary or distinctly localized type. The latter is the most frequent cause of stricture of the intestine. With disseminated tuberculous ulceration of the bowel, such as occurs in those dying of advanced tuberculosis of the lungs, the genito-urinary apparatus, etc., we have nothing to do. Further may be mentioned, as causes of ulceration which may require surgical treatment, pressure ulceration from foreign bodies, from distention above a stricture, from the pressure of fecal masses, and from malignant disease (carcinoma of the intestine); syphilis, pressure necrosis of the mucous membrane, and subsequent stricture in cases of reduced strangulated hernia.

Perforation of Typhoid Ulcer of the Intestines

Perforation of the intestine in the course of typhoid fever occurred, according to statistics collected by Harte and Ashurst (*Transactions of the American Surgical Association*, 1903), in 8,881 cases 225 times—2.54 per cent. The percentage varies a good deal in different years, falling as low as one per cent, and rising sometimes as high as ten per cent, or even more. It occurs more often in the white race than in negroes, and four times as often in men as in women. More than half the perforations take place during the second and third weeks of the disease; a very small number only during the first week, and about forty per cent after the end of the third week. Perforation is thought to be more frequent in severe types of the disease. Its occurrence appears to be favored by tympanites, the use of purgatives, sudden contractions of the abdominal muscles produced by the cold bath, and sudden movements of the patient. In other words, by mechanical causes. The form of the perforation varies from a minute orifice in the center of a Peyer's patch large enough to admit a knitting needle to a considerable oval orifice or slit. The former variety is thought to be due to ulceration, the latter to sloughing. The former is much more common. The perforation usually occurs upon the free border of the gut opposite the mesenteric attachment, rarely into the mesentery itself. The perforation is usually single. In 271 cases, mentioned by Harte and Ashurst, 236 times. In the remaining 35 it was multiple. Among their 190 collected cases where the seat of the perforation was noted, it was found in 140, or more than 73 per cent, in the ileum within a foot of the cecum. In only 4 cases was it more than 3 feet from the ileo-cecal valve.

In 7 cases only was the colon perforated. In 5 the ascending colon, once each the sigmoid and transverse colon. Meckel's diverticulum was perforated 3 times, the appendix 8 times. The regular result of perforation is a fatal progressive fibrino-purulent peritonitis. Only rarely localized with the production of an abscess; still more rarely the area about to become perforated may become adherent to an adjacent peritoneal surface, and the adhesions, being competent, result in cure. When an abscess forms and is incised a fecal fistula may remain, should the patient survive. From the peritoneal exudate, if operated on early, a pure culture of Bacillus typhosus may be cultivated in certain cases, and in these the peritoneal inflammation is of a less severe grade and the prognosis better than in those caused by streptococci, staphylococci, saprophytes, bacillus coli, etc. In these latter the exudate is more distinctly purulent and contains abundant fibrin; adhesions are early formed. The prognosis of streptococcus cases is much worse than those caused merely by the typhoid bacillus.

Symptoms and Diagnosis.—The signs and symptoms of perforation of a typhoid ulcer are the same as in perforation of the bowel under other conditions, modified in some instances by the existence of the specific disease. They are, in typical cases, sudden, sharp stabbing pain, referred to the lower part of the abdomen; frequently they are referred to the lower right quadrant of the belly—namely, to the place where the perforation has taken place. If immediate extravasation of intestinal contents occurs, and the patient is not apathetic from the typhoid poison or delirious, the pain will usually be continuous and severe. The patients may even scream and throw themselves about the bed. If, on the other hand, the amount of extravasation is very small, or if the perforation has taken place slowly, so that adhesions are formed, the pain may be merely the expression of moderate peritoneal irritation, and will not necessarily be severe. If the patient is apathetic and dull when the perforation takes place, he may not complain of pain at all.

Vomiting.—Vomiting is so common a symptom in typhoid fever that its occurrence alone has no diagnostic significance. Taken in conjunction with the sudden severe pain, it has a confirmatory value as indicating perforation. Especially is this the case if the patient has not vomited before. After peritonitis is established one or several acts of vomiting is the rule.

Temperature.—As in other cases of perforation of the intestine, the temperature may either become suddenly elevated as the result of septic absorption from the peritoneum, and this is the rule; still in other cases, if the patient is already greatly weakened by the disease, and if the extravasation be abundant, there may be a sudden fall of temperature accompanying the initial pain, sometimes with sweating. It was formerly maintained by medical men that this sudden fall in temperature, amounting sometimes to four or five degrees, was characteristic of typhoid perforation, and many were inclined to place upon it a positive diagnostic value. A closer observation of these cases leads us to the conclusion that, while such a fall of temperature

may occur, it is frequently absent, and that *a sudden sharp rise in the temperature curve* immediately following the perforation is the rule, and is far more characteristic than a sudden fall. In my own experience, every case of perforation seen has been immediately followed by a sudden rise of temperature, amounting to several degrees.

It frequently happens that the perforation is accompanied by a sharp chill.

The Pulse.—The pulse of typhoid fever is usually rather low as compared with the height of the temperature. With a temperature ranging as high as 103° or 104° F., typhoid patients usually have a pulse-rate, in the absence of complications, of about 100 beats per minute. When perforation occurs, a sudden rise in the pulse-rate to 120, 130, or 140 regularly takes place, and in the absence of the signs and symptoms of intestinal bleeding is very strongly suggestive of perforation.

Respiration.—Along with the accelerated pulse-rate the breathing becomes more rapid; but until the peritonitis has become fairly diffuse the breathing is not necessarily of the costal type.

Facial Expression.—Unless these patients are decidedly apathetic a sudden change in the expression of the face may usually be observed. The patient suddenly looks distinctly more ill. The face is pale and anxious, frequently in a few hours the countenance assumes the pinched and leaden facies of collapse.

Physical Signs.—Unless the patient is suffering from tympanites, the characteristic flat, boardlike abdomen is to be observed as in other cases of intestinal perforation. The rigidity is usually most marked in the lower right quadrant of the belly; frequently an inch or more to the right of the umbilicus, occasionally to the left of the middle line. The greatest point of tenderness, also, will usually be found in the lower right quadrant of the belly.

Percussion gives no positive diagnostic signs of value. General tympanites will frequently be present, and there may, of course, be absence of liver dullness, due to the distention of intestinal coils, very rarely to the presence of gas in the abdominal cavity.

The Blood.—It is to be borne in mind that the leucocyte count in typhoid fever without complications is normally low, notably during that period of the disease when perforation is most likely to occur. If during the second or third week of typhoid the leucocytes are counted daily, they will in the absence of complications usually vary between 5,000 and 7,000; in severe cases they may be much lower than this—from 2,000 to 4,000. The polynuclear cells will be reduced to 50, 60, or even to as low a figure as 35 per cent. In the event of perforation, marked leucocytosis may suddenly occur. Thus, Finney observed a sudden increase from 3,000 to over 16,000. In one of my own cases the leucocyte count, which had been 4,000 on the day preceding the perforation, suddenly rose to 12,000. More important, however, than the mere increase in the number of leucocytes, which in typhoid fever may be comparatively slight even in the presence of pyogenic complications, is the relative increase

in the polynuclear cells. Thus, in one of my fatal cases, although the total number of leucocytes rose only to 7,000 after perforation occurred, the polynuclear cells, which were previously only forty-six per cent, rose at once to ninety per cent. In very bad cases, however, where perforation occurs and the patient is already so feeble that no reaction takes place and the individual simply passes into a state of collapse from peritoneal sepsis, no notable change in the leucocytes may be observed before death.

Differential Diagnosis.—Hemorrhage.—While the symptoms of collapse frequently accompany intestinal hemorrhage as well as perforation in typhoid fever, in the former condition the blood is usually passed *per rectum* within an hour or two. The pain, tenderness, and abdominal rigidity regularly present in perforation are absent in cases of hemorrhage.

General Symptoms.—Extreme pallor, air hunger, and the like may sometimes be marked in bleeding from the bowel. When, as sometimes happens, the two conditions coexist, no differential diagnosis is necessary. The perforation demands immediate operation irrespective of the hemorrhage, and the surgeon may be fortunate enough at the same time that he closes the perforation to detect the source of bleeding, and check that, also. Appendicitis sometimes occurs as a complication in typhoid fever, although the differential diagnosis might sometimes be made from the typical point of tenderness in appendicitis, and usually from its less sudden onset, the appendicitis, if suppurative, requires operation irrespective of the existence of typhoid, and therefore, in the event of signs and symptoms indicating acute irritation of the peritoneum in the right lower quadrant of the abdomen, operation is indicated in either case. Peritonitis may also occur from other causes in typhoid fever; for example, mesenteric glands may suppurate and rupture into the peritoneal cavity. The signs of peritonitis will be present, and the indications are immediate operation. Acute inflammatory conditions of the tubes and ovaries can be differentiated from perforation by a combined abdominal and vaginal examination. Acute typhoid inflammation of the gall-bladder and biliary passages may occur as a complication of typhoid fever. They are to be differentiated from perforation sometimes by the occurrence of jaundice, and by the locality of the pain and tenderness in the region of the gall-bladder, sometimes by palpation of the distended gall-bladder. Rupture or perforation of the other abdominal organs and infection of the peritoneum—as, for example, from infarction of the spleen, perforation of a gastric or duodenal ulcer—will give the signs and symptoms of peritonitis, and will demand immediate operation, assuming that the condition of the patient is not too desperate.

Prognosis.—Practically all cases of typhoid perforation untreated surgically are fatal. An isolated case occurs now and then which recovers, or which comes later, after weeks or months, to the incision of an abscess; or such an abscess may possibly burst externally, leaving behind an artificial anus or a fecal fistula. But these cases are so rare as scarcely to be worth considering. By immediate operation, as soon as perforation can be diagnosticated, twenty

per cent or more of typhoid perforations are saved. The conditions are often most unfavorable, the patients being so far reduced by typhoid intoxication, by hemorrhages, pneumonias, or other complications that the perforation and septic intoxication simply comes as the last ounce of weight which breaks the feeble thread of life. Perforation having been diagnosticated, no matter how desperate the condition of the individual nothing is gained by delay. If operation is to be done at all it should be done at once. As already indicated, ether is a powerful heart stimulant, and should be used in preference to chloroform or to local anesthesia. Intravenous saline infusion may well be administered during the operation. The surgeon should surround himself with every aid to enable him to operate accurately and at the same time with the utmost dispatch. The matter of a few minutes on the operating table frequently determines the question of life or death in these cases.

I add brief histories of three cases of my own, one of them fatal, the other two ending in recovery, which will, I think, serve to indicate some of the diagnostic features of the condition:

Case I.—A girl, twelve years old, was admitted to the New York Hospital with a history and symptoms indicating that she was in the third week of typhoid fever. After having been in the hospital for five days she began, at four o'clock in the afternoon, to suffer from severe pain in the abdomen, localized more or less distinctly in the region of the umbilicus. During the next four hours she vomited three times. Her temperature rapidly rose from 100.5° to 105° F., her pulse from 90 to 130. Her leucocyte count, which had been 3,700 on the day preceding the perforation (no differential count made), rose during the evening to 8,600, with 82.5 per cent of polynuclear cells. Her respiration, which had been 24, became 44 per minute. During the night following the perforation she became delirious. I was not asked to see her until the following morning, and was only able to operate eighteen hours after abdominal pain had commenced. At this time her general condition was not very good. She appeared to be suffering from acute sepsis and moderate shock. Her abdomen was slightly distended. Tenderness and rigidity were marked over the lower half of the belly, but were most distinct in the right lower quadrant. The attempt was made to operate as rapidly as possible. As a matter of fact, after the incision was made in the skin, the patient remained on the table ten minutes. The abdomen was opened through a cut, three inches in length, made obliquely through all the muscular layers in the right iliac fossa outside the border of the rectus muscle. Upon opening the peritoneum a considerable quantity of intestinal contents were found free in the abdomen, together with fibrin and pus. There were some recent fibrinous adhesions, but no limitation by these to the spread of the infection. The ileum was rapidly drawn out of the wound; one foot from the cecum a swollen and slightly indurated Peyer's patch was found; at its center was a perforation about 3 mm. in diameter. This was closed by a purse-string suture surrounding the entire patch, reënforced by several mattress sutures placed in the line of the long axis of the gut. Suture material, fine silk. Abdominal cavity irrigated freely with hot salt solution through a large glass tube. Drainage by thin-walled rubber tube containing a gauze wick, introduced down to the point of perforation. The peritonitis was confined to the coils

of small intestine and to the pelvis. Partial closure of the wound by two through-and-through sutures of heavy silk. The patient reacted well after the operation. Her temperature fell at once to 100.5° F., but rose again from time to time, as is usual in these cases, probably as the result of typhoid infection. Her pulse remained rapid for a number of days; otherwise her convalescence from the typhoid fever and from the operation was normal. She was discharged from the hospital, well, thirty-seven days after the operation.

CASE II.—A man, twenty-five years of age, was under treatment in the New York Hospital for typhoid fever. On the forty-fourth day of his disease, when apparently convalescent, his temperature having been normal for a week, he was suddenly seized, at eleven o'clock in the morning, with violent pain in the abdomen. The pain was at first general, but was localized after two or three hours in the right lower quadrant of the belly. Three hours after the onset of his pain his temperature had risen to 102.8° F., and his pulse from 82 to 120. His leucocyte count, which had been low, rose to 12,000, with 82 per cent polymorphonuclear cells. He had vomited once. I first saw him at eight o'clock in the evening, nine hours after the onset of the pain. He appeared to be in a condition of fairly severe shock; his pulse was 144, and rather feeble. His temperature was 103° F. His abdomen was flat; there was marked tenderness and rigidity on the right side, most distinct in the lower right quadrant. Operation at once. Abdomen opened by an ordinary intermuscular incision in the right iliac fossa. The peritoneal cavity contained a considerable quantity of thin, yellowish sero-purulent fluid, but no pus nor any considerable quantity of fibrin. A perforation of the ileum was found six inches from the cecum. As the ileum was withdrawn through the abdominal wound it burst, and there was a squirt of intestinal contents. The Peyer's patch exhibited a slitlike perforation about a quarter of an inch in length. The surrounding surface of intestine was coated with fibrin, and apparently adhesions had formed to such an extent that very little, if any, of the intestinal contents had previously escaped. Irrigation was therefore considered unnecessary. Suture of the perforation by purse-string and mattress stitches. Partial closure of the wound, cigarette drain, normal convalescence.

CASE III.—A man aged twenty-two years was under treatment at the New York Hospital for typhoid fever. The first week of the disease had been characterized by frequent vomiting, nosebleed, and marked abdominal tenderness. During the second week of the disease he had five hemorrhages from the bowel, none of them large. Early in the morning of the twentieth day of his stay in the hospital he had a sharp chill. This was followed in four hours by a sudden severe abdominal pain. A second chill followed. His temperature, which had been ranging between 101.5° and 104.5° F., rose, following the chill, from 101.8° to 106.5° F. His pulse, which had ranged from 90 to 100, rose to 115. He felt nauseated, but did not vomit. He looked severely ill. When I examined him, about four hours after the onset of the pain, his abdomen was moderately distended and generally tender and rigid. Rigidity most marked in the right lower quadrant; point of extreme tenderness two inches to the right of the umbilicus. The abdomen was opened four and one half hours after the onset of the pain. Pus, fibrin, and intestinal contents were found. Cultures from the pus showed the presence of Streptococcus pyogenes. A perforation was found in the ileum seven inches

from the cecum. This was closed by suture, the belly washed and drained. As soon as the operation commenced the patient began to go to pieces; his pulse became very bad indeed, and his respiration shallow and irregular. All means of stimulation were used without effect, and he died twelve hours later, having passed into a condition of collapse from which he could not rally. The leucocyte count in this case was, one week before the perforation—leucocytes, 6,900, no differential made. Three hours after the perforation—leucocyte count, 1,600. An hour and a half later, just before the operation—leucocyte count, 2,400; polynuclears, 42 per cent; mononuclears, 58 per cent.

Tuberculosis of the Intestine

Tuberculosis of the intestine may for purposes of description be divided into three types:

1. **Disseminated Tuberculous Ulceration of the Bowel.**—Disseminated tuberculous ulceration of the bowel occurs as a part of severe and progressive tuberculosis of the lung, accompanied by uncontrollable diarrhea. The ulcers show no tendency to heal. The condition is an entirely hopeless one, and possesses no surgical interest.

2. **Ulceration of the Intestine, Confined Usually to the Ileo-cecal Region.**—The ulcers are of considerable size. They may be single or multiple. They occur most often in the ileum near the cecum, quite frequently in the cecum itself, or in the first portion of the ascending colon. While the disseminated form of tuberculous ulceration of the gut is always associated with phthisis of a severe type, these solitary tuberculous ulcers occur usually in cases suffering from the chronic or latent forms of tuberculosis of the lungs. The general condition of these individuals, while not good, is such that the tuberculous ulcers show at least some tendency toward healing, and a very decided tendency to cicatricial contraction. When, as often happens, these ulcers completely encircle the bowel, they may, upon healing or partly healing, cause stricture of the intestine. Of all the causes of chronic stenosis of the gut, this is the most frequent. Narrowing of the caliber of the gut may be produced by these ulcers in still another way: the ulcer may cause a localized peritonitis with the production of massive adhesions, and cause stenosis by angulation or by pressure. Although most frequent in the ileo-cecal region, such tuberculous ulcers are also found anywhere in the small intestine. The subjects of this form of tuberculosis are usually young people between twenty and thirty years of age. They are nearly always poorly nourished and feeble individuals, and very commonly have other tubercular foci in their bodies, or a history of a former tuberculosis. Tuberculous lymph nodes, tuberculosis of bones and joints, or a moderate grade of phthisis are quite commonly present. The disease ordinarily runs its course with the symptoms of chronic stenosis of the bowel, as already described. In making a diagnosis, the age, the general appearance of the patient, the presence of other signs of tuberculosis are highly important. In these cases, detection of tubercle bacilli in the feces is an im-

portant aid in diagnosis. The recognition of tubercle bacilli in the feces is not always easy. It may be done in one of two ways: The feces may be spread out upon a plate of glass or porcelain, and search made for little clumps of mucus covered by pus; smears may then be made from these masses of muco-pus, and stained for bacilli in the ordinary way, or the feces, *en masse*, may be placed in a sieve or strainer with meshes about as large as a knitting needle, and washed with a water bottle containing a weak solution of KOH. The wash water may then be placed in a centrifuge, and after long, thorough, and rapid rotation, may be examined for tubercle bacilli.

Perforation of Tuberculous Ulcers of the Intestine.—In from five to ten per cent of the cases perforation of the intestine occurs. This is more apt to be the case in the disseminated forms associated with advanced phthisis than with the solitary or few tuberculous ulcerations. When, as sometimes happens in the former class of cases, the perforation occurs suddenly into the general cavity of the peritoneum, the symptoms are those already described elsewhere under Peritonitis. The question of operation will depend upon the general condition of the individual. If he is in the last stages of phthisis, it is questionable whether it is worth while to operate at all. If the perforation occurs as the result of a solitary ulcer, or when the general condition of the patient is still good, immediate operation is, of course, indicated. As will be described when speaking of the third form of tuberculosis of the intestine, perforation rather rarely takes place into the free peritoneal cavity.

3. **Tuberculosis of the Ileo-cecal Region, with the Formation of a Tumor.**—Of very considerable interest from a diagnostic point of view is the not uncommon form of tuberculosis of the cecum and lower end of the ileum associated with the production of a definite tumor in the right iliac fossa. Whether this form of tuberculosis is ever a distinctly primary affection or is always secondary to tuberculosis of the lungs, of the mesenteric lymph nodes, or elsewhere, is not certainly known. The pathology of the disease was especially studied by Conrath. He separated the lesion into two types. In the first the disease commences in the peritoneal coat of the intestine as a localized tuberculous process with the formation of nodules which finally become confluent. In these cases the process probably originates in a caseous mesenteric lymph node. The process extends from without inward, finally to involve the mucous membrane of the gut and ulceration thereof, and is accompanied by extensive inflammatory thickening and hypertrophy of all the coats of the intestine so that the bowel forms a firm, knobby tumor; the lumen of the gut is thereby markedly diminished. The other form begins as a tuberculous ulcer of the mucous membrane of the cecum, or ileum, or both; more commonly the cecum is most extensively diseased. As in the other form, inflammatory hypertrophy with great thickening of the wall of the bowel, narrowing of its caliber, and the formation of a firm tumor, often of considerable size, is the regular result. In this form perforation—rarely sudden and acute, more commonly slow and gradual—may take place, but the most important symptoms are those due to

progressive stenosis of the bowel. The patients are usually young people, between twenty and thirty years of age. They are nearly always pale, feeble, and anemic, and frequently have tuberculosis of the lungs or of other organs. The symptoms produced are chiefly those of chronic progressive intestinal obstruction, although many cases may run a course lasting for months and years without any symptoms referable to the intestine other than occasional attacks of colicky pain or transient diarrheas. The presence of the tumor may be discovered by accident. Bleeding from the bowel is very rare. Tubercle bacilli may sometimes be detected in the feces. In those cases causing symptoms of stenosis, colicky pain, constipation alternating with diarrhea, disturbances of digestion, increased peristalsis in the small intestine, rumbling of the bowels, occasionally vomiting, in fact the ordinary symptoms of chronic intestinal obstruction, are present. Upon physical examination the tumor in the ileo-cecal region is often of such considerable size as to be visible upon inspection. Upon palpation a mass will be felt in the right iliac fossa, usually rounded, oval, or cylindrical in shape, extending a variable distance upward along the ascending colon. The tumor is not usually tender. Its surface is generally uneven, its consistence firm. In the earlier stages of the disease it is moderately mobile through an area whose borders are limited by the pelvic wall on the outer side and by a more or less flat, vertical arc to the left. Later in the disease adhesions are apt to be formed, and the tumor becomes more or less firmly fixed. Dullness or flatness may be present on percussion. Sometimes secondary tumors composed of masses of tuberculous lymph nodes may be felt on deep palpation. In a certain proportion of these cases the disease extends outside the bowel and produces tuberculous peritonitis. In other cases perforation of a chronic, more rarely of an acute, character takes place. When the perforation occurs gradually it may take place into a neighboring coil of intestine or into the urinary bladder. It may invade the blood-vessels or produce a right-sided tuberculous pleurisy, or it may gradually invade or perforate the abdominal wall. Sometimes the perforation is more acute with the signs and symptoms of a localized peritonitis with abscess. Pain, fever, localized tenderness, and rigidity will then be present. The condition may readily be confounded with appendicitis. In some cases the intestine itself will not be perforated, but the tuberculous mesenteric glands regularly present in the vicinity will break down and form a typical cold or tuberculous abscess. If let alone, such an abscess tends to perforate the abdominal wall. Quite rarely, as in a case I operated upon two years ago, sudden perforation into the general peritoneal cavity occurs, with all the signs and symptoms of acute perforative peritonitis. In the cases not attended by acute symptoms, but simply with the gradual formation of a tumor, and with no evidences of tuberculosis elsewhere in the body, the differential diagnosis from carcinoma of the cecum may be impossible even after opening the abdomen. I operated upon such a case a few months ago. The patient was a slender, feeble, and anemic woman, thirty-five years of age, who came to the hospital suffering from the symptoms of

slowly progressive chronic intestinal obstruction. There was a firm, movable, painless, insensitive, nodular tumor in the right iliac fossa extending upward three inches, somewhat cylindrical in shape and nearly as large as a man's fist. No history nor physical signs of tuberculosis were discoverable. Upon opening the abdomen the tumor had every appearance of a massive carcinoma of the cecum, and it was only after a pathological examination of sections under the microscope that the diagnosis of tuberculosis could be made. Another case upon which I operated is worth recording on account of its rarity. A slender, anemic young girl, aged eighteen, entered the New York Hospital to be operated upon for extensive tuberculous lymph nodes of the neck. The operation was done; the patient made a normal convalescence. She had never complained of any abdominal symptoms. She left the hospital and went to the Convalescent Home at White Plains, where she remained several weeks, and then returned to the hospital for the purpose of having a lymph node removed from the other side of the neck. On the evening of her admission she was suddenly seized with severe pain in the lower part of the abdomen; she vomited; had a rise of temperature with rapid pulse. I saw her early the next morning; the physical signs and symptoms seemed to be quite typical of a perforative appendicitis with progressive peritonitis. Upon opening the belly, purulent peritonitis with stinking pus and abundant fibrin was found occupying the right lower quadrant of the abdomen. The cecum was thickened and indurated; upon its anterior wall was a ragged perforation a quarter of an inch in diameter. The appearance of the ulcer, the scattered nodules of typical tuberculous peritonitis in the vicinity, and the enlarged and cheesy mesenteric lymph nodes rendered the diagnosis of sudden perforation of a tuberculous ulcer of the cecum quite certain. The patient's condition and the presence of an active peritonitis rendered a radical operation impossible at that time. The hole in the intestine was sutured, but the tissues were unfavorable for union, and the patient left the hospital some weeks later with a fecal fistula. After some months she entered the City Hospital, where her cecum was successfully excised by Dr. Howard D. Collins. The wound closed except for a small tuberculous sinus, not fecal, and she left the hospital improved in health. One year later she died, quite suddenly, of tuberculous meningitis.

In general, it may be said of ileo-cecal tuberculosis that the disease usually runs an exceedingly chronic course unless cured by a radical surgical operation. The outlook in these cases is not good; they ultimately fade away, and die of chronic intestinal obstruction, of phthisis, of some septic complication, of tuberculous peritonitis, or of general inanition.

Actinomycosis of the Intestine

The intestinal tract is, next to the head and neck, the most frequent seat of actinomycosis. The infection occurs from swallowing vegetable matters,

usually grain of some sort, containing the streptothrix of actinomycosis. The disease appears to occur much more frequently among farmers and such as live in the country than among the dwellers in cities, and more frequently attacks men than women. It has not been observed in children under ten years of age. As is the case with tuberculosis, the ileo-cecal region is more often affected than any other. As in other situations, the disease is a chronic inflammatory process with the abundant production of new connective tissue, the formation of granulation tissue of feeble vitality, which breaks down with the formation of pus. In the intestine the invasion of the new-formed tissue by the pyogenic and saprophytic germs of the bowel speedily leads to a mixed infection. All the coats of the intestine are invaded, and the process extends to the peritoneum with the production of massive adhesions; later the retroperitoneal tissues are invaded, or in other cases the disease infiltrates, and finally perforates the anterior abdominal wall. In nearly all cases, with very few exceptions, actinomycosis of the bowel runs, as elsewhere, a very chronic course. Grill, who made a special study of the topic, has divided the disease into three stages: First, a latent stage without symptoms; second, the formation of a tumor; third, penetration of the abdominal wall and the formation of fistulæ. In some cases the first stage is accompanied by the symptoms of catarrhal colitis, which may be slight or severe and may last for weeks or months before the appearance of a tumor. In many cases these early symptoms of irritation of the bowel are entirely absent until the formation of a tumor is recognizable. The situation of the tumor when formed depends upon the localization of the disease in the intestine. It is found more often in the ileo-cecal region than elsewhere. The tumor may be of any size up to the bigness of a fist. It is hard, insensitive, at first freely movable, and later becomes firmly fixed to the abdominal wall. This method of development is, however, quite exceptional. In most cases the tumor, when first discovered, will be in the nature of a diffuse, boardlike infiltration adherent to the abdominal wall, or forming a part thereof, or, if deeply placed, forming a firmly resistant mass in the retroperitoneal tissues, quite fixed and immovable. If the ileopsoas muscle is involved there may be muscular contracture and flexion of the thigh suggesting psoas abscess. The extent of the infiltration of the abdominal wall varies greatly; it may be quite circumscribed or involve an area as large as a dinner plate. As the infiltration proceeds the skin is gradually invaded here and there, at first with the production of firm and elastic plaques and nodules, which subsequently soften, break down, and discharge either the thin pus characteristic of actinomycosis and containing the characteristic granules, or these may long be absent. In many cases the pus will be foul-smelling and mixed with intestinal contents. The physical characters of these fistulæ are more or less characteristic. They run about here and there in an irregular and tortuous manner through the thickness of the abdominal wall. In a considerable proportion of cases it may be difficult to identify the characteristic granules in the discharge. Sections of the granulation tissue lining the sinuses

is more apt to give a positive result. Attempts to cultivate the organism from the pus will often fail on account of the more rapid and active growth of the saprophytic and pyogenic organisms present. The general symptoms produced by actinomycosis of the bowel vary greatly. The patients usually suffer from marked deterioration of the general health. Symptoms of stenosis of the bowel are rare. Fever is usually present, and will be more or less marked according to the extent of the accompanying pyogenic infection. The patients become emaciated and anemic. If the pus infection is severe, they will from time to time exhibit more or less marked leucocytosis. Although observed in a very few cases, a general infection of the entire body with the organism is extremely rare. One case of this kind was published by Zemann, in which the disease ran its course under the guise of an acute pyemia with the production of miliary nodules in various organs. Rupture into the free cavity of the peritoneum is also rare. Perforation of the abdominal wall may be accompanied by the formation of a fecal fistula. Other organs may be invaded—the liver, the pleura, the bladder, the kidney, or other portions of the gastro-intestinal tract. The prognosis of intestinal actinomycosis untreated surgically is most unfavorable. Of those who do not die of some acute pyogenic complication, many of them pass into a condition of chronic sepsis with amyloid degeneration of the organs—liver, kidney, spleen, etc. The results of surgical treatment, on the other hand, are rather favorable. Grill reported the results of surgical treatment in 111 cases. Of these 45 died, 22 were cured, 10 were improved, and the remainder still remained under treatment when the report was made.

Differential Diagnosis.—In the absence of sinuses and the recognition of the fungus in the discharge a positive diagnosis of actinomycosis of the intestine can hardly be made. In the rarer cases, exhibiting a movable tumor and symptoms of stenosis of the gut, the diagnosis from cancer would be impossible. When the disease occurs in the ileo-cecal region a number of conditions have to be considered: Carcinoma, ileo-cecal tuberculosis, appendicitis with the formation of a chronic abscess and sinuses, chronic inflammatory processes of the abdominal wall itself—namely, syphilis, tuberculosis, and chronic pyogenic infection; moreover, sarcoma and fibroma of the abdominal wall. The more diffuse and boardlike the infiltration the more probable is the diagnosis of actinomycosis. The extremely chronic character of the disease is also of diagnostic significance. When the infiltration is retroperitoneal it may be mistaken for retroperitoneal tumors or tumors of the pelvis, for psoas abscess from disease of the vertebra, or sacro-iliac disease. Careful study and observation of the case, and above all the recognition of the fungus from scrapings and discharges from sinuses, may be necessary for a positive conclusion.

TUMORS OF THE INTESTINE

Benign Tumors of the Intestine

Benign tumors are occasionally observed in the bowel. Their occurrence is not very frequent, and in a large proportion of cases they cause no symptoms, and are merely of pathological interest. When they do give rise to trouble it is usually in one of three ways: 1. They may cause intussusception by being dragged along the gut by peristalsis until the base of the tumor forms the beginning of an invagination which may later become complete. 2. They may undergo malignant degeneration. 3. When they grow to a considerable size they may cause obturation. The following varieties have been observed: adenoma, lipoma, fibroma, myoma, myxoma, teratoma, mixed forms of innocent growths, and combinations of innocent growths with sarcoma. The *adenomata*, except when they occur as polypoid growths of the rectum, give no clinical symptoms unless they cause intussusception. At the operation done for the relief of this condition the adenoma may be discovered as a cause. They may undergo carcinomatous degeneration. The *lipomata* are only of interest as a cause of invagination. The *myomata*, composed of unstriped muscle fibers, are of more clinical interest, since they may grow to a considerable size and form palpable tumors producing symptoms mechanically. The myomata may occur at any age. As in the stomach, they may grow into the caliber of the gut, or outwardly into the peritoneal cavity. The former are usually smaller tumors than the latter. Internal myoma weighing a pound has been observed. External myoma may reach a large size and weigh many pounds. These tumors may be sessile or pedunculated; the former grow to the larger size. They are composed of unstriped muscle fiber and connective tissue. Of the internal myomata, the small ones rarely cause any symptoms; the larger may cause invagination or obturation of the bowel. They are rarely discoverable by abdominal palpation. The symptoms of obturation may be continuous and severe or remittent; occasionally these internal myomata may undergo ulceration, or even sloughing. The external myomata, if small, produce no symptoms. If large, they may act mechanically to drag the intestine and its mesentery downward, and thus cause displacement of the viscera, occasionally digestive disturbances or constipation, possibly true intestinal obstruction by pressure or angulation or, if they form adhesions, by strangulation. Clinically, if large enough to be palpable they will exhibit themselves as very slowly growing, painless, movable tumors; by their age alone and the absence of symptoms their benignancy may be rendered probable. It is to be remembered, however, that at any time they may undergo sarcomatous degeneration. The other forms of benign tumor of the intestine are much more rare. Occasionally they may cause symptoms, obturation or invagination, such as have been described.

Cystic Tumors of the Intestine

While retroperitoneal and mesenteric cysts of various kinds and origins are by no means rare, cystic tumors of the gut itself are among the greatest of pathological rarities. In an article (*Amer. Jour. Med. Scs.*, January, 1906) J. C. Ayer, of New York, described a very unusual cystic tumor which occurred in the cecum of a case upon which he operated. The patient was a man who had suffered several attacks of abdominal pain, and who entered the hospital with symptoms pointing to a fairly acute appendicitis, although no fever was present, or to partial obturation of the bowel. Upon opening the abdomen a cystic tumor of the cecum was discovered. The appendix was normal. The cyst lay in the cavity of the cecum, and was attached over about one fifth of its surface to the posterior or attached wall of the cecum. The wall of the cyst was dense and firm; its contents were about four ounces of clear, viscid fluid. The origin of the cyst was not determined; it was thought to have arisen from a fetal "rest" in the mesocolon, and gradually grown into the intestine. It might well have caused partial obturation of the bowel. Only a very few cases of cysts of the wall of the gut are reported.

Under the name Pneumatosis cystoides intestinorum hominis, E. Hahn described a case of multiple cysts of the intestinal wall containing odorless noninflammable gas or air. The cysts were very numerous, and lay in the muscular coat of the gut, chiefly along the free side of the intestine. The cysts varied in size from that of a pea to a hazelnut. The clinical history of this case was as follows: The patient had suffered from constipation. He gradually developed marked tympanites. "There could be felt in the belly large, elastic, tense tumors, everywhere tympanitic. The sensation resembled that experienced when palpating multiple echinococcus cysts of the peritoneum." Improvement followed operation. Kadjan reported a similar case in 1902: A thirty-one-year old, cachectic woman suffered from constipation, vomiting, later ascites. Tuberculous peritonitis was found at operation. In addition, very numerous gas-filled cysts scattered over the small intestine, fewer on the large intestine, varying in size from the head of a pin to a plum. She was reoperated after a time; the tubercle nodules had disappeared. The air cysts remained.

Malignant Tumors of the Intestine

Both carcinoma and sarcoma occur in the intestine; the former much more frequently than the latter—twenty to one, or thereabouts. Carcinoma affects chiefly the large bowel, its especial home being the rectum. Sarcoma occurs in the large and small intestine with about equal frequency. When in the large intestine it resembles carcinoma in that the rectum is by far the most frequent site. Sarcoma of the bowel may occur at any age. It is most frequent during the fourth decade of life. Men suffer oftener than women. Various forms have been observed: Small round- and large round-celled, spin-

dle-celled, melano, alveolar, lympho-sarcoma, cysto-sarcoma, as well as other forms. Malignant endotheliomata resembling sarcomata in their clinical characters also occur, as well as combinations of sarcoma with tuberculosis—i. e., the development of sarcoma upon a tuberculous inflammation of the bowel as a basis. Certain more or less characteristic distinguishing differences exist between sarcoma and carcinoma of the bowel. Sarcomata are apt to form much larger tumors than carcinomata. Carcinomata usually cause stenosis of the gut, sarcomata less commonly. The gut may be dilated with sarcoma. Sarcomata tend to invade surrounding structures by continuity; carcinomata tend to remain confined to the intestine for a longer time. A larger area of intestinal wall is involved in sarcoma than in carcinoma. Metastases occur through the lymphatics and blood-vessels in sarcoma of the bowel involving mesenteric glands and forming large tumors of the mesentery, as well as metastatic tumors of the kidney, liver, stomach, etc., earlier than in carcinoma. Sarcoma runs, in general, a more rapid course than carcinoma, causing death usually within a year when it occurs in the small gut. The tumor grows rapidly. Ascites, cachexia, and metastasis occur early. A positive differential diagnosis between sarcoma and carcinoma of the small intestine can scarcely be made before operation. A rapidly growing, large tumor in the central region of the belly without symptoms of obstruction of the lumen of the gut would favor sarcoma. The prognosis of sarcoma of the bowel, even after early operation, is unfavorable.

Carcinoma of the Intestine.—Epithelial cancer affects the large intestine much more frequently than the small, and the rectum more often than any other part of either. Bovis collected a large number of cases. His statistics were as follows, relating to the location of the disease: Small intestine, 6.3 per cent; ileo-cecal region, 11.9 per cent; sigmoid flexure, 11.9 per cent; other parts of the colon, 20.4 per cent; rectum, 49.2 per cent; the entire large intestine, excluding the rectum, 44.2 per cent. In other words, the rectum is the most frequent site of cancer of the bowel; the ileo-cecal region and the sigmoid flexure are the next most frequent sites; the hepatic and splenic flexures next. Like cancers elsewhere, the disease is one of advanced life, and yet by no means always; extreme youth does not exclude the possibility of cancer in diseases of the intestine, as was pointed out in Diseases of the Stomach; cancer may occur in young adults, and even in children. Males are affected three times as often as females. The forms of cancer occurring in the intestine are several. By far the most common is cylinder-celled cancer of the glandular type; medullary and scirrhous forms are comparatively rare. The tumor is usually single. The tendency to the formation of secondary tumors in distant organs is not very marked. Cancers of the bowel show two marked tendencies: 1. To break down and ulcerate and to bleed; to perforate into the peritoneal cavity or into neighboring viscera. 2. To surround the gut and cause stenosis of its lumen by contraction of the fibrous stroma of the tumor. The spread of the disease takes place locally into the mesentery and

into the peritoneum, causing cancerous peritonitis and ascites; further, to spread through the lymphatics and blood channels, producing secondary tumors in the liver and in distant organs, the bones, etc. The most prominent symptoms caused by cancer of the gut are those due to narrowing of its caliber—namely, the symptoms of intestinal obstruction; such may be slowly progressive, finally to become absolute; on the other hand, the early symptoms may be so slight as scarcely to attract attention. Moderate digestive disturbances with constipation, such as is common enough in elderly people, or diarrhea, or alternations of the two, is suddenly succeeded by the symptoms of acute and absolute intestinal obstruction. (See section on Acute and Chronic Obstruction.) In some cases, along with the signs and symptoms of *chronic intestinal obstruction*, or without such, a *tumor* of greater or less size will be discoverable. (See Diagnosis of Abdominal Tumors.) When obstructive symptoms are present, the presence of a tumor may render the nature and seat of the growth more or less certain. In the cases attended by *progressive* symptoms, in addition to disturbances of digestion, constipation, diarrhea, attacks of colicky pain, there will be present more or less marked, according to the situation of the tumor and the degree of stenosis, local signs in the abdomen, such as increased peristalsis, dilatation of the afferent bowel, etc., as described under Chronic Intestinal Obstruction. As already indicated, the tumor may be very small or so deeply placed in the abdomen as to escape palpation. If a tumor is palpable it will usually feel hard and smooth; it may be tender or insensitive, and will exhibit a degree of mobility depending upon what portion of gut it occupies, and whether or not it has become adherent to surrounding structures. The difficulty in feeling a tumor will be greatly increased by a thick abdominal wall or marked tympanites. The passage *per rectum* of small amounts of blood or blood-stained muco-pus, or of fragments of tumor tissue, though by no means constant, will, if present, aid the diagnosis. They are usually present in the later stages of the disease. The lower down in the bowel the growth the more marked and evident will these signs be, until in the lower sigmoid they merge into those of cancer of the rectum. The peculiarly fetid character of the stools in such cases has already been noted. As to determining what portion of the bowel is involved, assuming that a tumor is felt, some of the data have been given under the Diagnosis of Tumors of the Abdomen, others under Chronic Intestinal Obstruction. Here may be added that tumors of the colon, with the exception of the sigmoid and transverse colon, occupy a characteristic position and possess a degree of passive immobility quite in contrast with the very mobile small intestine. Tumors of the sigmoid possess a somewhat variable degree of mobility; in the average case, however, the home of such a tumor will be in the left lower quadrant of the belly, and generally, from the signs and symptoms mentioned as characteristic of obstruction of the large and small intestines respectively, the diagnosis can be made at least with probability. In a certain proportion of cases cancer of the bowel runs an almost or entirely latent course up to a late period of the

disease. In such cases a progressive *cachexia*, rupture into the general peritoneal cavity, and diffuse purulent peritonitis, into the urinary bladder, with escape of feces and gas from the urethra and the speedy development of a severe cystitis, may be the first definite signs of the nature of the disease. In some cases, together with cachexia, the patient will develop signs of irritation of the peritoneum and ascites. It must be confessed that in the absence of very definite signs and symptoms the diagnosis of cancer of the bowel is by no means always possible. As stated, it may be quite impossible to differentiate it from the tumor formed by ileo-cecal tuberculosis. It may rarely quite closely resemble chronic intussusception in an adult or, indeed, be associated therewith. The more rapid growth of sarcoma and absence of the signs of stenosis may serve as a means of differentiation. One condition the surgeon should always have in mind in elderly people, whether constipated or suffering from diarrhea, and that is fecal impaction. When the least doubt exists, or even when the surgeon is quite certain a tumor is present in the bowel, nothing will be lost and much may be gained by giving a series of large, stimulating enemata, and after the bowel is known to be empty making a second examination of the abdomen. A large number of conditions may be confounded with cancer of the gut. Among those to be mentioned and elsewhere described are actinomycosis, tumors of the mesentery, and of the greater curvature of the stomach; in the upper part of the abdomen, tumors of the gall-bladder and pancreas, tumors of the kidney and movable kidney, chronic inflammatory exudates of various kinds and in various situations; space will not permit a separate discussion of all these in this place. The causes of death in cancer of the intestine have been already indicated; most frequently these patients die of intestinal obstruction; occasionally from cancerous cachexia, exhausting diarrhea, aided by sepsis and toxic absorption from the alimentary canal; rather rarely from penetration and infection of the general cavity of the peritoneum with intestinal contents. When the disease perforates into the urinary bladder they may die of cystitis and an ascending infection of the kidney. Sometimes they die of an intercurrent disease; rather rarely from the interference with the function of other organs by metastatic tumors.

The duration of life in cancer of the intestine is very variable, and rather difficult to determine accurately. It is greater in cancer of the large intestine than in cancer of the small bowel. It may be said to vary from six months to six years, possibly even longer; two years, about, on the average. If the cancer is placed low down in the large intestine, the formation of an artificial anus may prolong life for a number of years, the patient living meanwhile in comparative comfort. The results of the radical removal of cancer of the intestine have greatly improved in recent years on account of the more perfect surgical technic recently developed. A percentage of cures as high even as thirty per cent has been obtained by certain surgeons.

THROMBOSIS OF THE MESENTERIC VEINS

Under Acute Intestinal Obstruction the history of a typical case of embolism of the superior mesenteric artery with gangrene of the intestine is related. Thrombosis of the mesenteric veins presents no symptoms which enable us to make a differential diagnosis from the former condition. The conditions leading to such thrombosis may be trauma from accidental injury to the abdomen, or during surgical operations on the intestine, or from the reduction of a strangulated hernia, marasmus, obstruction to the portal circulation, as in cirrhosis of the liver, and in thrombophlebitis. The symptoms are those of acute intestinal obstruction with symptoms of shock, with or without profuse hemorrhage from the bowel or vomiting of blood. Upon opening the abdomen a greater or less extent of small intestine will be found wholly or partly gangrenous. One successful case of operation for these conditions is reported by Sprengel; one by Elliot.

TUMORS OF THE PERITONEUM, OMENTUM, AND MESENTERY

While the number of tumors occurring in peritoneum and mesentery, occasionally in the omentum, whether as primary growths or as an extension from tumors of the abdominal organs or as metastatic growths, is fairly large, it is comparatively rare that they can be positively diagnosticated as such before opening the abdomen except in some cases by inference, as in carcinomatosis of the peritoneum secondary to tumors of the abdominal viscera and the like. It seems best, however, briefly to mention some of the commoner forms.

Carcinoma of the peritoneum is usually secondary to carcinoma of the stomach, bowel, ovary, etc. They occur as multiple tumors scattered over the peritoneum, at first of small size, later often growing into nodular, palpable masses, frequently situated in the omentum. Along with the growth of the primary tumor producing its own symptoms of whatever kind, and the progressive cachexia of advanced cancer, there occurs an abundant effusion of clear, sometimes cloudy, brownish or *blood-stained* fluid into the peritoneal cavity. If the primary tumor remains undiscovered the condition may be mistaken for tuberculous peritonitis.

Benign Tumors of the Mesentery, Retroperitoneal Tissues, and Omentum.—Fibroma, lipoma, myxoma, and combination forms have been observed. They are slowly growing tumors, and if they cause symptoms at all, do so by weight and pressure. Those which grow from the retroperitoneal connective tissues of the posterior abdominal wall are usually but slightly movable. The others, of course, exhibit a very variable degree of mobility. Any of these tumors may reach a considerable size. An exact diagnosis is impossible before operating.

Cystic Tumors of the Peritoneum, Mesentery, and Omentum.—Multiple echinococcus cysts of the peritoneum have been observed. They are usually secondary to an echinococcus cyst of the liver or elsewhere which has ruptured; very rarely are they primary in the peritoneum. Cysts of the mesentery may arise in several ways: (1) Echinococcus cysts of the mesentery have been observed in a moderate number of cases; twenty-nine such cases were collected by an Italian observer (Nannotti) in 1889. (2) Embryonic cysts from remains of fetal organs; Wolffian and Müllerian bodies, fetal inclusions. (3) Cystic malignant disease; Keen reported a case of a large cystic sarcoma of the mesentery. (4) Dermoids of the mesentery have occurred in moderate number. These various cysts may contain fluid of various kinds—serum, chyle, blood, degenerated blood, cholesterin, etc. (See, also, Dermoid Cysts, under Tumors.) The mesenteric cysts developing in the mesentery of the small gut are movable, rounded, smooth, firmly elastic tumors, lying usually below the level of the umbilicus. They may fall into the pelvis, but can be pushed up into the abdominal cavity. Cysts developing in the transverse mesocolon are less movable. In the cysts of the mesentery, "if the colon be inflated with air, it is sometimes possible to see the distended gut surrounding the cyst like a collar" (Körte). These cysts may cause serious disturbances by pressure on the intestine.

Similar cysts producing similar physical signs may develop in the omentum. *It is in the highest degree undesirable and dangerous to introduce an aspirating needle through the abdominal wall into a cystic tumor of the abdomen, centrally situated as these tumors are, and not known to be firmly adherent to parietal peritoneum, for the purpose of determining its contents and character.* Not only may intestine be punctured, but infectious or irritating material from the cyst itself may well be distributed throughout the belly in this way. The only proper diagnostic and therapeutic measure other than palpation, etc., is an aseptic abdominal incision.

Tumors arising from embryonic displacements, remains, etc., in the interior of the abdomen are some of them cystic, some of them solid or partly solid tumors. They are, with the exception of dermoids arising from the ovaries, rare tumors, and hardly likely to be diagnosticated as such before operation. Dermoids of undescended testes are also observed. Lexer, who wrote a monograph on the topic, divided them into three groups: dermoids, fetal inclusions, and teratoid mixed tumors. The dermoids other than those of the ovary and testis are found most often in the mesentery of the small intestine and in the great omentum. The fetal inclusions lie most often in the transverse mesocolon, sometimes in the mesentery or retroperitoneal tissues. The teratoid mixed tumors are partly solid, partly multilocular cystic tumors. They are exceedingly rare in the abdomen. Inclusions of more or less perfectly developed fetuses have been recorded. Thus Ayer says: "Himly, in an autopsy upon a female child, aged two and a half years, found a cystic tumor in the epigastrium, which contained a fairly well-developed fetus, with

however, defective extremities and head. Klebs reported the case of an infant in whom independent motions were observed within an abdominal tumor; the child died a few weeks after birth, and at the autopsy a cyst was found behind the transverse colon, composed of peritoneum and amnion, and containing an umbilical cord to which was attached a partially developed fetus." Other similar cases have been reported.

CHAPTER IV

APPENDICITIS

ANATOMY

The most fixed point of the vermiform appendix—namely, its base—lies in the average case in the right iliac fossa behind a point two inches from the anterior superior spine of the ilium and on a line joining this bony point with the umbilicus (McBurney's point). The position of the more movable portion of the appendix varies a good deal in different individuals, and to a certain extent in the same individual at different times. Its most common direction is upward and to the left, pointing toward the spleen. It may hang downward into the pelvis; lie anteriorly in contact with the abdominal wall, extend upward and backward entirely behind the cecum or in the direction of and even in contact with the right kidney, directly across the abdomen to the left, or indeed in any possible direction. The tip of the appendix may lie in contact with the stomach, with the urinary bladder, with the Fallopian tube. Not very rarely it may form the contents of a hernial sac, whether inguinal or femoral. As was explained under congenital anomalies of the intestine, congenital displacement of the cecum is accompanied by a corresponding displacement of the appendix. The base of the appendix lies at the lower extremity of the anterior muscular band on the surface of the colon. This band, if followed downward, forms a very certain guide to the base of the appendix. Normally, the appendix is entirely an intraperitoneal organ. When retrocecal, it occasionally lies outside the peritoneum in the retrocecal connective tissue. Sometimes, from antecedent peritonitis, this extraperitoneal situation may be simply an encasement in the new connective-tissue formation of adhesive peritonitis. In other cases it is due to early adhesion and obliteration of the contiguous peritoneal folds covering the posterior abdominal wall and the peritoneal covering of the colon respectively. In some cases, whether due to congenital peculiarities in its peritoneal investment or to antecedent peritonitis, a portion of the appendix, most often its tip, sometimes its middle, sometimes its base, will be found covered by peritoneum, while the remainder of the organ lies outside the peritoneal cavity. In some cases the appendix will be found closely adherent to the cecum throughout its length. These very varied relations to peritoneum are important surgically, and are often the factors which determine in the given case whether a perforative lesion

of the appendix results in a localized abscess with very slight involvement of the peritoneum, or whether, on the other hand, the perforation takes place into the free peritoneal cavity to produce a more or less violent peritoneal sepsis or some other severe form of peritonitis. The appendix possesses a mesenteriolum of variable length, thus determining the degree of mobility of the organ to a considerable extent. The arteries, veins, and lymphatic channels of the appendix are included in the mesenteriolum. The arterial supply is derived from the ileo-cecal branch of the ileo-colic branch of the superior mesenteric. In the female an additional blood supply is derived from the right ovarian artery. The veins empty into mesenteric veins (portal system). The lymphatics empty into the mesenteric lymph nodes. The nerves are derived from the celiac plexus of the sympathetic. The length of the appendix is very variable. It may be reduced to a mere nubbin; or, on the other hand, may be as long as eight inches. Its average length is estimated at from 5 to 8 cm. The caliber of the appendix is small, 4 to 5 mm. A fold of mucous membrane at the junction of the appendix with the cecum, "Gerlach's valve," acts in such a manner as to hinder to a greater or less extent, or in some cases to prevent, the entrance of the contents of the cecum into the appendix. In structure the appendix resembles the large intestine, though differences exist; the appendix possesses rather a feeble muscular coat. The mucous membrane of the appendix is characterized by the presence of very closely grouped mucous crypts and follicles. These are extremely abundant until about the thirtieth year of life, when they atrophy, become smaller and fewer until old age, and in a considerable proportion of cases in persons of over sixty years or even much earlier, this atrophy proceeds to a partial or even total obliteration of the appendix. Such obliteration may involve the entire length of the canal, a fortunate occurrence for the individual, or only a portion of its distal extremity; or, on the other hand, may result in narrowings of any part of the lumen. In what proportion of operative cases the strictures so commonly found are due to simple atrophy, and in how many to antecedent inflammation, it is difficult to answer. The submucous layer of the appendix is particularly rich in lymphoid tissue. The arrangement of the glandular structures and of this lymphoid tissue affords an opportunity for pyogenic infection as favorable as any to be found in the human body.

NOTE.—The appendix is very rarely absent. As far as I am able to learn, only five cases have been reported in which no trace of an appendix was found (G. S. Huntington).

CAUSES OF APPENDICITIS

The micro-organisms concerned in inflammation of the appendix are of varied character. Any of the pus-producing germs may be present in the contents of an inflamed appendix or an appendical abscess or peritoneal exudate. The one most frequently found is Bacillus coli communis, often associated

with Streptococcus pyogenes, sometimes with one or other of the pyogenic staphylococci. Other varieties to the number of forty or more have been identified with greater or less frequency. Bacillus typhosus, the tubercle bacillus, the streptothrix of actinomycosis, are occasional invaders of the appendix. Bacillus coli, a very vigorous form always present in the intestine, and, as stated, very commonly found in appendicitis, has, no doubt, crowded out in many cases, notably in localized abscesses not opened for several days, other germs, originally associated with it in the beginning. The conditions favoring infection of the appendix are local and general. Locally, the anatomical peculiarities of the appendix render it especially liable to pyogenic invasion. The narrow caliber of the canal is readily constricted or occluded from slight causes; a catarrhal swelling of the mucous membrane of the cecum may readily close the valvelike orifice of the appendix, and retention of contents under slight tension with some congestion of its mucous membrane furnishes here, as elsewhere, the most favorable opportunity for infection. The tissues of the appendix resemble those of the tonsil in their readiness to take up pyogenic germs. Antecedent attacks of inflammation, or even a stricture the result of partial atrophy of the mucous membrane, may furnish similarly favorable conditions for infection. As in the urethra or other narrow mucous canal attacks of inflammation are followed by the formation of new connective tissue surrounding the tube, and this, as time goes on, inevitably contracts, forming a stricture. Congenital malformations of the peritoneum surrounding the appendix are common. Moreover, if inflammation of the appendix has extended to the peritoneum, pathological adhesions are readily produced, and thus we find in many cases as a cause of acute appendicitis sharp bends or kinks in the wall of the appendix. Such adhesions may, moreover, compress the blood-vessels of the appendix, producing disturbances in its circulation in the nature of congestion, swelling of the mucous membrane, and retention of its contents.

Atony of the intestine, catarrhal enteritis or colitis, acute diseases—such as typhoid fever or scarlet fever or dysentery—syphilitic or tuberculous ulceration of the gut, etc., may all cause changes in the character of the secretions, in the contents, or in the circulation of the appendix, and lay it open to bacterial inflammation and infection. These same causes may also interfere with the lumen of the appendix, and it is easy to conceive that an appendix free from anatomical and pathological kinks and strictures may be temporarily so compressed between folds of small intestine, or between small intestine and cecum, or between gut and floor of the iliac fossa, as to suffer traumatism in some of its coats; or, through such compression, its circulation may be interfered with to such an extent that anemia or venous engorgement may be induced (McBurney).

It was pointed out by Robert T. Morris that during the normal involution of the appendix, which may occur after the age of thirty years, pain and discomfort in the region of the appendix may be produced, owing to the contrac-

tion of the connective-tissue framework of the appendix upon its nerves, and that without any inflammatory condition whatever. Upon examining such appendices it is discovered that the inner layers of the appendix have been entirely replaced by connective tissue. The symptoms produced are not always distinctive, and the condition can hardly be recognized clinically as a diagnostic entity. Blake, in 1905, in a paper, "Malposition of the Appendix as a Cause of Functional Disturbances in the Intestine," related the histories of a number of cases who suffered from attacks of abdominal pain, usually in the right lower quadrant of the abdomen, sometimes accompanied by distention of the bowel with gas and constipation, but without the symptoms of acute inflammation of the appendix, no fever, nor marked tenderness. The attacks of pain were generally accompanied by constipation or evidences of intestinal fermentation, such as diarrhea and distention of the bowel with gas. Purgation usually gave temporary relief. The patients were nearly all of them women, most of them were neurasthenic. In two out of ten cases the evidences of enteroptosis were well marked, and in two the right kidney was distinctly movable. In most of the cases traction was exerted on the cecum through the appendix by a short meso-appendix; in a few the cecum seemed to be suspended by the appendix, being adherent behind the colon. Blake explained the condition in the following way:

It is well known that the cecum in late intra-uterine life descends from a position immediately below the liver to its normal one in the right iliac fossa. The descent is due rather to an increase in length of the descending colon than to a dropping of the colon. As the length of the colon increases, its vessels must also increase proportionately, or a folding of the gut will occur.

In the class of cases under discussion this disparity of growth occurs, and a folding of the gut results at the junction of the cecum with the appendix from an inadequate growth of the vessels in the mesenteriolum. As these vessels normally pass behind the ileo-colic junction, the appendix is held up behind that point, and through it the end of the cecum. In many instances a sharp kink of the appendix occurs at the point where its main vessel reaches it.

In some of the cases it appeared as if a constriction of the ileum might readily occur by an overdistended cecum and ascending colon drawing it down over the band produced by the short meso-appendix.

With such a mechanical relation of these structures, it would seem that the symptoms complained of by these patients could be caused in the following ways—namely, by the tugging on the appendix and meso-appendix produced by an overdistended or overloaded cecum; by a partial obstruction produced either in the ileum or the colon by their bending over the fixed appendix; or possibly by interference with the circulation of the cecum and ascending colon.

The irritation and traumatism caused by the presence of a foreign body is an occasional but rare cause of appendicitis. What part the presence of fecal concretions play in the production of appendicitis it is not quite easy to answer. Such concretions are very commonly found at autopsy in individuals who

have never had appendicitis. They lie always upon the distal side of a stricture in the appendix. It is probable that, once being formed, they gradually increase in size, until by pressure they create an atrium of infection in the mucous membrane of the appendix, or by occluding its lumen cause stagnation and accumulation of the contents of the appendix, favoring an increase in the number and activity of the bacteria, and furnishing, as in other cases of stricture occlusion, conditions favorable for infection. As predisposing causes of appendicitis, it is to be remembered that the appendix, being an organ undergoing involution, may well afford a place of diminished resistance. This has been strongly urged by certain writers (Pozzi), who considers it for this reason a favorite port of entry for germs in general systemic infections.

OCCURRENCE

Appendicitis is a rare disease in infants less than two years old. After sixty years of age, largely on account of the atrophy which regularly takes place, it is again rare. Even after the age of forty the disease becomes much less frequent. For some reason not entirely clear the disease occurs four times as frequently in men as in women. The causes of this disparity may lie in the fact that men are more likely to indulge in overeating and drinking than women, and thus to cause congestion and swelling of the mucous membrane of the bowel; and, further, that men are more exposed to injuries and lead more active lives, make more violent, sudden muscular efforts, and thereby, perhaps, cause pressure upon the appendix by muscular action. To some extent appendicitis may be influenced by heredity. It is not at all infrequent that several brothers in the same family suffer from appendicitis; in other families, though large, no member suffers. It was pointed out by Blake that this might be due to the fact that in certain families the appendix occupied such a position and such a relation by its mode of attachment to the cecum that twists and kinks were more apt to occur.

SYMPTOMS AND DIAGNOSIS OF APPENDICITIS

All the forms and varieties of appendicitis are attended by two common symptoms—namely, abdominal pain and vomiting—but the intensity of these symptoms varies greatly in the different types of the disease. For purposes of description it is convenient to classify the affections of the appendix under several heads: (1) Appendicular colic; (2) catarrhal appendicitis; (3) suppurative appendicitis; (4) perforative appendicitis; (5) gangrenous appendicitis; (6) chronic appendicitis, which may be subdivided into a relapsing and a recurrent form.

1. Appendicular Colic.—Until with a few years the question of whether distinct attacks of pain in the region of the appendix, which might be characterized by the term appendicular colic, were or were not always accom-

nied by an inflammatory lesion of the appendix, remained unanswered. At the present time it can certainly be answered in the negative. The types of disturbance which may occur without any inflammation have some of them been indicated already when quoting from Morris and Blake—namely, those due to involution changes in the appendix and those due to unusual positions and attachments of the appendix, and the mechanical effects thereby produced upon the cecum and ileum or upon the appendix itself. An appendix the seat of bends and kinks, whether congenital or acquired, may have its caliber narrowed to such an extent as to dam back the feces or mucus which it may contain, and thereby set up a spasm of the muscular coat of the organ, accompanied by sudden and severe sharp attacks of pain, often by vomiting. In these cases there will be no rise of temperature. On account of the depression produced by the pain and vomiting, there may be a fall of temperature below the normal. The pulse also will not be accelerated, or if accelerated, but slightly so; on account of the pain and vomiting the pulse may be soft and compressible. During the attack of pain there may be moderate abdominal tenderness in the right iliac fossa, and such tenderness may remain over the appendix for some days. The pain will be felt in the abdomen; it will come on suddenly. At first it may be a general abdominal pain, or it may be referred to the epigastrium, or to the umbilicus. If the pain last several hours, it will after a time be referred to the right iliac fossa. Such attacks of pain may be due to the presence of a fecal concretion in the appendix. Whether due to this cause or to a kink or bend, the attack, after lasting for a few hours or a day, will subside; the patient will at no time appear to be seriously ill; while the pain lasts there may be several attacks of vomiting and slight or moderate constitutional depression. There is a marked tendency in these cases for the attacks of pain to recur at frequent, though somewhat irregular intervals. In a fairly large proportion of cases such attacks will be followed by one or other of the forms of acute appendicitis.

2. **Catarrhal Appendicitis.**—In this form of the disease the causes are similar to those just described—a kink, a stricture, a fecal concretion, a foreign body in the appendix, or some other mechanical condition which prevents the appendix from emptying itself; but in these there is added a catarrhal inflammation of a mucous membrane of the appendix, caused by infection. The mucous membrane will swell, the amount of its secretion will be increased, it will be markedly hyperemic. Thus the mechanical obstruction is increased, the point of narrowing being sometimes at the base of the appendix, sometimes in some other part due to the actual stricture or kinking, as the case may be. The appendix becomes distended with the catarrhal secretion, the bacteria find a favorable soil for multiplication; they invade the mucous membrane and the lymphoid, submucous layer of the appendix. In other words, a true inflammation is present. As in appendicular colic, the attack will begin suddenly with abdominal pain and vomiting; the pain, at first general or felt in the epigastrium, will be localized in a few hours in the right iliac fossa. Upon

pressure with the tip of the forefinger over McBurney's point there will be marked tenderness. The vomiting is apt to be more severe and persistent than in mere colic; it will consist, first, of the contents of the stomach, and if repeated acts of vomiting occur it will be bile-stained. Accompanying the pain and the vomiting there will be an elevation of temperature and an acceleration of the pulse-rate. During the first twenty-four hours the temperature may rise to 101°, 102°, or 103° F. The pulse-rate will vary from 90 to 120 or more beats a minute. Although the pain may be severe and local tenderness well marked, the abdominal wall will remain soft. If it be found rigid in the right iliac fossa, the case cannot be regarded as one of catarrhal appendicitis merely. The rigidity is positive evidence of peritoneal irritation. In these cases there is usually moderate constitutional depression, which lasts perhaps for several days. At the end of one, two, or three days the fever, the pain, and the tenderness begin to subside, the appendix manages to overcome the obstruction wholly or partly, or at least the inflammation undergoes partial resolution, and the symptoms subside for the time. At the end of three or four days the temperature and pulse will again be normal, the pain and tenderness will have disappeared, and the patient will seem to have regained his normal health.

3. Suppurative Appendicitis.—The disease may begin without previous illness. In a good many cases there will have been a history of attacks of colic or of one or more attacks of catarrhal appendicitis. The lesion in this case is a suppurative one. All the coats of the appendix are involved, the lesion may be a general one, or may be confined to some particular portion of the appendix. The pyogenic infection has occurred usually on the distal side of a stricture or at a point in the mucous membrane where the resistance of the tissues has been diminished by catarrhal inflammation, by the traumatism of a foreign body, or fecal concretion. The point of entry of the bacteria is often very small, in many cases microscopic. Minute pus foci are formed in the mucous membrane. These break down and produce an ulcer of greater or less extent. The secretion of the mucous membrane is increased, becomes muco-purulent or puriform. The appendix becomes distended with highly infectious material. If the peritoneal coat of the appendix is involved in the inflammation, as is usually the case, a localized peritonitis about the appendix occurs with a fibrinous exudate. The subsequent history of the lesion and of the patient varies. If the inflammation has not advanced far enough to cause peritonitis, the attack may gradually subside, but the appendix will remain permanently damaged; as the result of the ulceration a permanent stricture will be formed which will predispose to subsequent attacks of inflammation. In other cases the lumen of the appendix will be obliterated at some point, and distal to that there will be within the cavity of the appendix a collection of pus or muco-pus, which may remain indefinitely without causing serious symptoms (empyema processus vermiformis), or which, as is much more likely to be the case, will at some future time set up a more violent inflammation. In a few cases the lumen is totally closed at some point, but the inflammation ceases. The appen-

dix remains as a closed sac (hydrops processus vermiformis). In other cases when the peritoneum is involved a more or less extensive fibrinous peritonitis will cause adhesions between the appendix and the abdominal wall, or between the appendix and the cecum, or with other coils of intestine, or with the Fallopian tube, the ovary, the urinary bladder, or some other organ. In other cases more or less extensive agglutination of the surrounding intestinal coils buries the appendix in a mass of adhesions. (See also Chronic Adhesive Peritonitis.) In other more severe cases the wall of the appendix will be penetrated by pyogenic germs, although such penetration is not necessarily accompanied by a macroscopic lesion. In these cases the irritating effects of bacterial toxins will have by agglutination of the surrounding structures closed off the infectious focus in the appendix from the peritoneal cavity, and when the bacteria finally penetrate the peritoneum and multiply outside the appendix they will produce not a diffuse peritonitis but a localized abscess. If the adhesions are very dense, it sometimes happens that such an abscess will remain small, and cease to spread. In such an event it is possible that the process may stop here; the bacteria in the abscess cavity may die, and the whole focus undergo caseation or calcification. Such a result is, however, exceptional. More commonly the abscess continues to increase in size, and may spread in several directions: into the pelvis between the cecum and the abdominal wall, upward along the ascending colon toward the liver, rarely across the abdomen among the coils of small intestine; occasionally it may rupture into the cecum, into the ileum, into other viscera, or through the abdominal wall. (See section on Localized Peritonitis for the different routes by which infection spreads in the peritoneal cavity.)

The history of an attack of suppurative appendicitis in a typical case is as follows: The patient is seized, as in the preceding form, by severe abdominal pain and vomiting. The pain, with no definite localization at first, becomes fixed in a few hours in the right iliac fossa. Together with the pain the patient has a rise of temperature, very rarely accompanied by a chill. The rise of temperature may be only of one or two degrees, or the temperature may rise quite rapidly to 103° or 104° F. There will be a corresponding acceleration of the pulse. At first the pulse is commonly 100, full, and bounding, as the disease progresses the pulse tends to become more rapid as the septic poisoning becomes more intense, the pulse-rate is often temporarily increased by the attacks of vomiting. Pressure over McBurney's point elicits marked local tenderness; *the lower right quadrant of the abdominal wall is rigid.* This last sign is, as already pointed out, probably the most important in the diagnosis of acute appendicular lesions; when absent, although the surgeon may feel that the case demands most careful watching, yet it cannot be said that the necessity for immediate operation is urgent. (Though I recently saw a gangrenous appendix with no rigidity.) When present it is an infallible sign that serious mischief is going on in the appendix, or that the peritoneum is irritated and inflamed. In the opinion of the majority of surgeons, in which opin-

ion I concur, it is an indication for immediate operation. Palpation of the abdomen in the vicinity of the appendix will in case an abscess is present, or the neighboring intestines are glued together by fibrinous adhesions, reveal the presence of a more or less distinct mass, unless the appendix hangs down into the pelvis or is in some other more or less unusual position. The time of appearance of a palpable mass in the abdomen varies. It may be felt during the first day of the disease, or not for several days, according as perforation and peritoneal involvement occurs early or late. In many cases ordinary superficial palpation will reveal no mass at any time. Deep palpation is painful in the extreme in these acute cases, and moreover dangerous, since a slightly walled-off abscess may thus be ruptured into the free and noninfected cavity of the peritoneum with possibly deadly results. Often the surgeon, having made the diagnosis of acute appendicitis merely, will wait until the patient is on the operating table under ether before making deep palpation through the then relaxed abdominal wall. The discovery of a mass at this time is a valuable guide to the most desirable position for the abdominal incision. It is easier and rather safer to approach the lesion from the outer side. The size and position of the mass will vary. In some cases the mass will consist of a portion of inflamed omentum inclosing the appendix. (See also Localized Peritonitis.) If a large piece of omentum or several coils of gut are inflamed, edematous and glued together by a fibrinous exudate, the mass may be as large as one's fist or larger. If the appendix lies just beneath the abdominal wall, in front of or to the outer side of the cecum, the mass will be near the spine of the ilium. If the appendix lies to the inner side of the cecum, the mass will approach the middle line. If it be a retrocecal appendix, no mass may be felt, or only on deep palpation, and covered in front by the tympanitic colon. If the process has extended upward along the front or to the outer side of the ascending colon, the mass may be palpable far up in the right hypochondrium; there will be marked tenderness in the lumbar region; the right thigh will often be flexed and adducted in these cases. In neglected cases when a large abscess has formed and infiltrated the abdominal wall there may be edema of the overlying skin, as well as a boardlike infiltration of the underlying muscular layers. In such cases there may be edema of the entire right lower extremity from pressure upon the iliac veins. Such cases are now but rarely seen. Twenty or more years ago they were not very uncommon in the hospitals of New York. Rectal and vaginal palpation should not be omitted in case no mass is felt through the abdominal wall. If no abscess exists nor any extensive peritonitis, it is in some cases possible to feel the enlarged and swollen appendix itself. If the appendix lies just beneath the abdominal wall, it may, in the absence of extreme tenderness and rigidity, be palpated quite readily. It may feel like a more or less rigid rod as large as a lead pencil, rarely as thick as one's little finger, or as a nodule projecting from an area less firm. In other cases when deeply placed and with a thick abdominal wall such palpation will be quite impossible. A certain number

of surgeons allege that in a large proportion of cases they are able to palpate the appendix even when quite deeply placed, and but little if any changed in size and consistence. Although my experience has not been small, I have never been able to acquire the skill and delicacy of tactile sensibility necessary to feel the normal appendix at all, except under very favorable conditions. The remainder of the abdomen is usually not markedly distended and tympanitic in the cases of localized peritonitis or abscess. Percussion over the region of the appendix does not, as a rule, afford very valuable information. If a massive exudate is present around the appendix, dullness, even flatness or modified tympanitic resonance, may be present. But in the majority of instances, unless an abscess is quite large and in contact with an abdominal wall, no very definite information is obtainable by this means. In the more favorable cases in which the inflammation is confined to the appendix itself the acute symptoms may subside in the course of a few days or a week. Tenderness over the region of the appendix may persist for an indefinite time or even until the attack is renewed. If the process results in an abscess the septic symptoms, instead of getting better, will continue to grow worse, as already described under localized peritonitis. A tumor will be formed in the region of the appendix, which will usually continue to increase in size, and since such an abscess is apt to be surrounded by a dense barrier of adhesions, the outlines of the tumor may be very distinctly marked indeed. If not operated upon, the subsequent history of these cases of abscess is quite varied. As already stated, if the abscess be small, cure is even possible without operation, the abscess may become encapsulated, and its contents finally undergo degenerative changes, or absorption, or calcification. Such an event is, however, rare. In some cases the abscess will finally rupture into the general cavity of the peritoneum, and produce one or other of the forms of fatal diffuse peritonitis. In other cases the abscess may rupture into the intestine (the rectum, the cecum, or the ileum), with partial amelioration of the symptoms. In other cases these patients will go on to die of general septicemia or of some local septic process, such as septic pneumonia, septic pleuritis, subphrenic abscess, suppuration of retroperitoneal lymph nodes, abscess of the liver from suppurative inflammation of the portal vein; sometimes from chronic septic poisoning and exhaustion. Only very rarely does an abscess the result of appendicitis rupture spontaneously through the abdominal wall.

4. **Perforative Appendicitis.**—Perforative appendicitis may present several varieties. If the individual has suffered from previous attacks with involvement of the peritoneum, the appendix may have become an extraperitoneal organ, or in certain cases, as already indicated, this condition may be congenital, as in some of the forms of retrocecal appendix. Under these circumstances perforation of the appendix, whether sudden or gradual, will result in a localized abscess, and the history of the case will not differ from the abscesses formed in the cases of suppurative appendicitis without gross perforation. It is to be borne in mind that an intraperitoneal abscess, if thor-

oughly encapsulated by fibrinous adhesions, may cease, at least for a time, to produce the symptoms of acute sepsis. After a sudden onset, with marked local signs, a considerable rise of temperature, an accelerated pulse, and a relatively high polynuclear leucocyte count, and the formation of a tumor, it may happen at the end of a few days that the temperature gradually falls to normal, the leucocytosis disappears, the abscess ceases to give acute pain, so that an ignorant or careless observer might conclude that the patient was improving. In the meantime, however, the pulse-rate remains accelerated; the patient remains weak, has no appetite, becomes progressively anemic. Such a condition may persist for days or weeks. Sooner or later the process nearly always again becomes active. One sees such cases occasionally following operations for progressive fibrino-purulent peritonitis due usually to appendicitis, the later trouble arising often from some small focus between intestinal coils not reached at the first operation. The presence of such a focus may be suspected for days without our being able to locate it. In other cases the patient may appear to be almost safely convalescent, when rupture and diffuse peritonitis may appear like a bolt out of the blue sky and destroy the patient's life, in spite of our best efforts. In other cases the perforation may occur either suddenly or slowly with involvement of the peritoneal cavity. A good many of these cases will never have suffered from an attack of appendicitis before. The perforation will usually be associated with the presence of a fecal concretion which has caused pressure necrosis of the wall of the appendix. In other cases with a stricture of the appendix which has become impervious. Some portion of the wall of the appendix undergoes ulceration, and the entire thickness of its wall being finally perforated, the highly infectious contents of the appendix escape into the peritoneal cavity. If some protecting adhesions are already present or have time to form, and especially if Bacillus coli alone is present, the result is a progressive fibrino-purulent peritonitis, or under the most favorable conditions an abscess which tends to spread pretty rapidly, and often finally to rupture into the free peritoneum. If the perforation is sudden, and there are no limiting adhesions, and especially if streptococcus is the organism contained in the inflamed appendix, the result is peritoneal sepsis or diffuse purulent peritonitis. These cases furnish the strongest argument for immediate operation in cases of acute appendicitis as soon as the diagnosis can be made. Very often they do not appear to be severe cases at the start. The patient is seized with the ordinary symptoms of acute appendicitis of moderate severity. In the course of one, two, or three days the appendix ruptures, the patient suddenly suffers from excruciating abdominal pain and vomiting. He often passes into a state of collapse, with a very rapid, feeble pulse, a boardlike abdomen, sometimes retracted, sometimes more or less tympanitic, and all the signs and symptoms of peritoneal sepsis or diffuse purulent peritonitis, as described under Peritonitis. I have seen so many of these cases die who might have been saved had the operation been done during the first day or two of the disease, when the patient was in good condition, the peritoneum not in-

ed, and the symptoms and signs of acute appendicitis perfectly distinct, ough not apparently threatening, that I have gradually been forced to conclusion, based upon the observation of many hundreds of cases through-

FIG. 22.—VERMIFORM APPENDIX, SHOWING CONSTRICTION AT THE BASE.

t the last nineteen years, that in the absence of conditions rendering opera- n especially difficult or dangerous, such as chronic alcoholism, obesity, the istence of some other serious acute or chronic disease, I believe the safest

FIG 23.—APPENDIX OPEN, SHOWING CONCRETIONS NEAR THE TIP.

cedure is to remove the appendix as soon as a diagnosis of acute inflamma- n of that organ can be made. The opinion of a majority of American rgeons of large experience in the surgery of the appendix agrees with s view.

5. **Gangrenous Appendicitis.**—This is the most severe and dangerous form the disease. The infection is of so intense a character that the whole a considerable portion of the appendix becomes gangrenous, frequently in- ding its mesenteriolum, and even a portion of the wall of the cecum. In me cases only one half or only the tip of the appendix becomes gangrenous. others, if operated upon very early, we may observe that the process extends om within outward, so that while the peritoneal coat is still of a deep red

color, or at a later stage pale grayish-yellow, the interior coats of the organ are of a dirty green or grayish-green, and totally gangrenous from one end to the other. When operated upon a little later, the gangrene has included all the coats, and the swollen organ presents itself as a greenish-black or greenish-gray putrid slough. In the worst cases of this type of the disease the clinical picture is that of sudden overwhelming peritoneal sepsis; rupture of the putrid appendix furnishes a dose of bacterial toxins, such that the resisting powers of the peritoneum and of the entire organism are paralyzed at once. Soon after the onset of the attack the patient sinks into a condition of collapse. Temperature subnormal. Pulse, rapid, feeble, and compressible, 120 to 140 or more beats a minute. Vomiting; a retracted, boardlike abdomen, which may later become tympanitic from paralysis of the gut, if the patient survive for two or three days. From this condition of early shock and collapse the patient may never rally. Death may occur within two or three days. When operating upon one of these cases we find the peritoneal cavity contains neither pus nor fibrin; there are no limiting adhesions whatever. A small or moderate quantity of thin brownish or blood-stained serum escapes from among the coils of intestine. The peritoneal surfaces look dull, but are scarcely reddened. If the condition has existed for a day or two the visible coils of gut are distended and paralyzed. From the vicinity of the gangrenous appendix a drachm or two of brown or greenish, putrid, stinking fluid escapes. The subsequent course of these cases varies, and depends upon whether the dose of poison already absorbed is lethal or not, and in the latter case whether the focus of infection can be so far removed as to prevent a further extension of the process and fatal poisoning. Further, upon the resisting powers of the individual, upon the virulence of the particular culture of germs present, and to some extent upon the local and general measures used for the relief of the patient. In the bad cases the patients may, as stated, not rally from their collapse, and die in the course of from twenty-four to forty-eight hours, becoming delirious, then stupid and apathetic, and finally comatose. In some of those cases who survive for a number of days certain peculiarities are to be observed in the condition of the wound. The tissues show not the slightest evidence of a reparatory effort. No granulations are formed upon the wound surfaces. At the end of a week or ten days the incision in the abdominal wall may, if the patient survives so long, look as though it had been just made. In the meantime little or no purulent discharge will have escaped. The discharge will be small in quantity, have a foul and putrid odor, of a brownish or greenish-gray color. In other cases the wound edges will become gangrenous. In the cases who survive for a few days the peritoneal sepsis produces total paralysis of the gut, the abdomen becomes distended with gas, the bowels cease to move, the patient vomits, and the vomited material assumes after a few days a distinctly fecal character.

There are other types of septic intoxication accompanying gangrenous appendicitis which, though fatal in the end, run by no means so stormy a course. These are cases already described of septic thrombophlebitis of the portal vein

with suppuration in the liver, to which is sometimes added pyemic abscesses in the lung, in the kidneys, in the spleen, and elsewhere. These cases often run a subacute course, and life may be prolonged for several weeks. In the most favorable cases when the surgeon is fortunate enough to operate on his patient before the septic intoxication has advanced too far, or before the entire thickness of the wall of the appendix has become gangrenous, or septic thrombosis of the mesenteric veins has occurred, the prognosis is fairly good, depending largely upon the resisting powers of the individual.

6. **Chronic Appendicitis.**—An appendix which has once been inflamed is nearly always a menace to the health and life of the individual. In a large proportion of cases successive attacks of inflammation occur, and the tendency is rather for the attacks to become more severe in character; sometimes they are distributed at irregular intervals over a period of years; in favorable cases the successive attacks of inflammation lead to obliteration of the appendix, and thus to a cure of the disease. In other cases the appendix is left in a damaged state, such that the individual is never entirely free from discomfort; the lesion is sometimes a hydrops of the appendix or a mucous inclusion, as the condition is designated by Robert T. Morris. Sometimes an empyema. In some of these cases the appendix will have formed adhesions to the cecum, a small abscess will have been produced which perforates the large intestine. Thus an opening may be left, communicating, on the one hand, with the appendix, and on the other with the cecum. In these cases the individual will never be free from discomfort, and the disease may go on for years with or without another attack of acute appendicitis, depending upon the local conditions, as already described. When a patient suffers from repeated attacks of appendicitis separated by considerable intervals, the condition is spoken of as *relapsing appendicitis.* When the intervals between the attacks are very short, or when the patient continues to suffer more or less constantly, the condition is known as *recurrent appendicitis.* The symptoms of these chronic forms of appendicitis vary somewhat; in the relapsing cases the successive attacks are accompanied by the ordinary symptoms of acute appendicitis more or less severe. In the relapsing cases the patient may suffer from a continuous sense of discomfort in the region of the appendix, oftentimes with localized tenderness. There will usually be a tendency to constipation of the bowels rather than to diarrhea. From time to time the patient will have a sharp attack of pain, accompanied by nausea and vomiting and moderate prostration. The symptoms accompanying malposition of the appendix, and sometimes attending involution changes in the organ, have already been mentioned.

Diagnostic Value of the Blood Count in Suppurative Conditions, especially Appendicitis.—In no other acute inflammatory disease has the diagnostic value of leucocytosis been more carefully studied than in appendicitis, and up to within a rather recent time with at best but indefinite results. At present our knowledge of the subject is becoming somewhat more precise. While I do not think I have ever decided for or against an operation for appendicitis solely

on the evidence of the blood count, nor have ever based a positive or negative diagnosis upon this evidence, yet from a prognostic point of view there can be no question but that certain types of leucocytosis furnish very valuable data. In the *New York Medical Record* of March 25, 1905, Dr. Frederic E. Sondern published a short article on the "Present Status of Blood Examinations in Surgical Diagnosis." Dr. Sondern's reputation, large experience, and careful methods entitle his opinions to respect, and the conclusions briefly stated in his paper are so carefully and conservatively drawn, and agree so completely with my own experience in surgery, that I shall utilize in the following paragraphs the data given in his paper to a considerable extent. As a general proposition, it may be stated that in acute suppurative and gangrenous conditions an increase in the number of the leucocytes of the blood may be present or absent. Further, that a mere general increase of leucocytes indicates a good resistance on the part of the individual rather than the intensity or gravity of the infection, and that, further, in the most severe forms of infection with poor resistance, leucocytosis may be and usually is absent or slight. Thus a very slight infection with good resistance may produce a leucocytosis of 25,000 or more, while a sudden grave septicemia in a feeble individual may show no increase at all. On the other hand, a marked relative increase in the polynuclear neutrophiles is found to be a very valuable indication indeed. As a practical measure of comparison of considerable value, I insert a table prepared by Dr. Sondern, based upon the examination of about five thousand blood specimens taken from healthy adults of the upper and middle classes of society in the city of New York, with but few hospital patients among them:

Leucocytes in 1 c.mm. of blood from 5,200 to 9,600, the average being 6,700. These figures were determined by the use of the Thoma-Zeiss chamber, almost invariable dilution 1:100 and actual count of corpuscles in 0.1 c.mm. of blood in most instances.

The same tables show a normal differential count of leucocytes to be as follows:

Leucocytes.	Percentages.			Actual number in 1 c.mm. based on average leucocyte count of 6,700.
	Low.	High.	Average.	
Small lymphocytes	24	35	28.0	1,876
Large lymphocytes	3	10	7.5	502
Polynuclear neutrophiles	59	68	62.0	4,154
Eosinophiles	0.2	4	1.0	67
Basophiles	None	0.4	0.2	7

These figures are based on percentages obtained from actual count of at least 500 corpuscles in the center, and not on the margin of the blood smear.

The following conclusions may be drawn in regard to the value of the differential count: First, a relative percentage of polynuclear cells below seventy with an inflammatory leucocytosis of any degree excludes the presence of gan

rene or pus at the time the examination is made, and usually indicates ood resistance toward infection. A relative increase in the polynuclear cells with little or no inflammatory leucocytosis is a positive indication of an inflammation, and the percentage increase of polynuclears varies directly with the severity of the infection. With a polynuclear percentage below seventy neither pus nor gangrene is to be expected. Children have a lower percentage of polynuclear cells than adults, and among them a percentage only slightly above seventy may indicate suppuration. In adults, pus or gangrene is usually accompanied by a relative increase of polynuclear cells of at least eighty per cent. Sondern says eighty-five per cent or over of polynuclear cells always indicates a purulent exudate or a gangrenous process, irrespective of the total leucocytosis. Ninety per cent of polynuclear cells always indicates a severe degree of infection and poor resistance. Ninety-five per cent, especially with a low general leucocyte count, is almost of fatal significance. When the general leucocyte count is high, similar conclusions may be drawn from the presence of similar percentages of polynuclears. The absolute grade of general leucocytosis remains a fair index to the reaction of the tissues, and with a given percentage of polynuclears a high leucocyte count indicates a better resistance than a low one. That is to say, with a given inflammatory lesion and a polynuclear percentage of, say, 85, a leucocytosis of 30,000 indicates much better resistance than one of 15,000. If with a very high polynuclear count the total number of leucocytes is only 7,000, it indicates that the system is offering little or no resistance to the infection. This is the type of leucocytosis which we commonly find in the worst forms of peritoneal sepsis and diffuse purulent peritonitis. Gibson has constructed a chart, the coördinates of which are the leucocytosis and the relative increase in polynuclear cells. His conclusions are as follows:

The differential blood count and its relation to the total leucocytosis is to-day the most valuable diagnostic and prognostic aid in acute surgical diseases that is furnished by any of the methods of blood examination.

It is of value chiefly in indicating fairly consistently the existence of suppuration or gangrene, as evidenced by an increase of the polynuclear cells disproportionately high as compared to the total leucocytosis.

The greater the disproportion the surer are the findings, and in extreme disproportions the method has proved itself practically infallible.

As the relative disproportion between the leucocytosis and the percentage of polynuclear cells is of so much more value than the findings based on a leucocyte count alone, this latter method should be abandoned in favor of the newer and more reliable procedure.

The negative findings showing no relative increase or even an actual decrease of the proportion of the polynuclear cells, while of less value, shows, with rare exceptions, the absence of the severer forms of inflammation.

In its practical applications, the method is of more frequent value in the interpretation of the severity of the lesions of appendicitis and their sequelæ.

In order to have some standard to measure disproportion of the polynuclear

pressure with the tip of the forefinger over McBurney's point there will be marked tenderness. The vomiting is apt to be more severe and persistent than in mere colic; it will consist, first, of the contents of the stomach, and if repeated acts of vomiting occur it will be bile-stained. Accompanying the pain and the vomiting there will be an elevation of temperature and an acceleration of the pulse-rate. During the first twenty-four hours the temperature may rise to 101°, 102°, or 103° F. The pulse-rate will vary from 90 to 120 or more beats a minute. Although the pain may be severe and local tenderness well marked, the abdominal wall will remain soft. If it be found rigid in the right iliac fossa, the case cannot be regarded as one of catarrhal appendicitis merely. The rigidity is positive evidence of peritoneal irritation. In these cases there is usually moderate constitutional depression, which lasts perhaps for several days. At the end of one, two, or three days the fever, the pain, and the tenderness begin to subside, the appendix manages to overcome the obstruction wholly or partly, or at least the inflammation undergoes partial resolution, and the symptoms subside for the time. At the end of three or four days the temperature and pulse will again be normal, the pain and tenderness will have disappeared, and the patient will seem to have regained his normal health.

3. Suppurative Appendicitis.—The disease may begin without previous illness. In a good many cases there will have been a history of attacks of colic or of one or more attacks of catarrhal appendicitis. The lesion in this case is a suppurative one. All the coats of the appendix are involved, the lesion may be a general one, or may be confined to some particular portion of the appendix. The pyogenic infection has occurred usually on the distal side of a stricture or at a point in the mucous membrane where the resistance of the tissues has been diminished by catarrhal inflammation, by the traumatism of a foreign body, or fecal concretion. The point of entry of the bacteria is often very small, in many cases microscopic. Minute pus foci are formed in the mucous membrane. These break down and produce an ulcer of greater or less extent. The secretion of the mucous membrane is increased, becomes muco-purulent or puriform. The appendix becomes distended with highly infectious material. If the peritoneal coat of the appendix is involved in the inflammation, as is usually the case, a localized peritonitis about the appendix occurs with a fibrinous exudate. The subsequent history of the lesion and of the patient varies. If the inflammation has not advanced far enough to cause peritonitis, the attack may gradually subside, but the appendix will remain permanently damaged; as the result of the ulceration a permanent stricture will be formed which will predispose to subsequent attacks of inflammation. In other cases the lumen of the appendix will be obliterated at some point, and distal to that there will be within the cavity of the appendix a collection of pus or muco-pus, which may remain indefinitely without causing serious symptoms (empyema processus vermiformis), or which, as is much more likely to be the case, will at some future time set up a more violent inflammation. In a few cases the lumen is totally closed at some point, but the inflammation ceases. The appen-

dix remains as a closed sac (hydrops processus vermiformis). In other cases when the peritoneum is involved a more or less extensive fibrinous peritonitis will cause adhesions between the appendix and the abdominal wall, or between the appendix and the cecum, or with other coils of intestine, or with the Fallopian tube, the ovary, the urinary bladder, or some other organ. In other cases more or less extensive agglutination of the surrounding intestinal coils buries the appendix in a mass of adhesions. (See also Chronic Adhesive Peritonitis.) In other more severe cases the wall of the appendix will be penetrated by pyogenic germs, although such penetration is not necessarily accompanied by a macroscopic lesion. In these cases the irritating effects of bacterial toxins will have by agglutination of the surrounding structures closed off the infectious focus in the appendix from the peritoneal cavity, and when the bacteria finally penetrate the peritoneum and multiply outside the appendix they will produce not a diffuse peritonitis but a localized abscess. If the adhesions are very dense, it sometimes happens that such an abscess will remain small, and cease to spread. In such an event it is possible that the process may stop here; the bacteria in the abscess cavity may die, and the whole focus undergo caseation or calcification. Such a result is, however, exceptional. More commonly the abscess continues to increase in size, and may spread in several directions: into the pelvis between the cecum and the abdominal wall, upward along the ascending colon toward the liver, rarely across the abdomen among the coils of small intestine; occasionally it may rupture into the cecum, into the ileum, into other viscera, or through the abdominal wall. (See section on Localized Peritonitis for the different routes by which infection spreads in the peritoneal cavity.)

The history of an attack of suppurative appendicitis in a typical case is as follows: The patient is seized, as in the preceding form, by severe abdominal pain and vomiting. The pain, with no definite localization at first, becomes fixed in a few hours in the right iliac fossa. Together with the pain the patient has a rise of temperature, very rarely accompanied by a chill. The rise of temperature may be only of one or two degrees, or the temperature may rise quite rapidly to 103° or 104° F. There will be a corresponding acceleration of the pulse. At first the pulse is commonly 100, full, and bounding, as the disease progresses the pulse tends to become more rapid as the septic poisoning becomes more intense, the pulse-rate is often temporarily increased by the attacks of vomiting. Pressure over McBurney's point elicits marked local tenderness; *the lower right quadrant of the abdominal wall is rigid.* This last sign is, as already pointed out, probably the most important in the diagnosis of acute appendicular lesions; when absent, although the surgeon may feel that the case demands most careful watching, yet it cannot be said that the necessity for immediate operation is urgent. (Though I recently saw a gangrenous appendix with no rigidity.) When present it is an infallible sign that serious mischief is going on in the appendix, or that the peritoneum is irritated and inflamed. In the opinion of the majority of surgeons, in which opin-

ion I concur, it is an indication for immediate operation. Palpation of the abdomen in the vicinity of the appendix will in case an abscess is present, or the neighboring intestines are glued together by fibrinous adhesions, reveal the presence of a more or less distinct mass, unless the appendix hangs down into the pelvis or is in some other more or less unusual position. The time of appearance of a palpable mass in the abdomen varies. It may be felt during the first day of the disease, or not for several days, according as perforation and peritoneal involvement occurs early or late. In many cases ordinary superficial palpation will reveal no mass at any time. Deep palpation is painful in the extreme in these acute cases, and moreover dangerous, since a slightly walled-off abscess may thus be ruptured into the free and noninfected cavity of the peritoneum with possibly deadly results. Often the surgeon, having made the diagnosis of acute appendicitis merely, will wait until the patient is on the operating table under ether before making deep palpation through the then relaxed abdominal wall. The discovery of a mass at this time is a valuable guide to the most desirable position for the abdominal incision. It is easier and rather safer to approach the lesion from the outer side. The size and position of the mass will vary. In some cases the mass will consist of a portion of inflamed omentum inclosing the appendix. (See also Localized Peritonitis.) If a large piece of omentum or several coils of gut are inflamed, edematous and glued together by a fibrinous exudate, the mass may be as large as one's fist or larger. If the appendix lies just beneath the abdominal wall, in front of or to the outer side of the cecum, the mass will be near the spine of the ilium. If the appendix lies to the inner side of the cecum, the mass will approach the middle line. If it be a retrocecal appendix, no mass may be felt, or only on deep palpation, and covered in front by the tympanitic colon. If the process has extended upward along the front or to the outer side of the ascending colon, the mass may be palpable far up in the right hypochondrium; there will be marked tenderness in the lumbar region; the right thigh will often be flexed and adducted in these cases. In neglected cases when a large abscess has formed and infiltrated the abdominal wall there may be edema of the overlying skin, as well as a boardlike infiltration of the underlying muscular layers. In such cases there may be edema of the entire right lower extremity from pressure upon the iliac veins. Such cases are now but rarely seen. Twenty or more years ago they were not very uncommon in the hospitals of New York. Rectal and vaginal palpation should not be omitted in case no mass is felt through the abdominal wall. If no abscess exists nor any extensive peritonitis, it is in some cases possible to feel the enlarged and swollen appendix itself. If the appendix lies just beneath the abdominal wall, it may, in the absence of extreme tenderness and rigidity, be palpated quite readily. It may feel like a more or less rigid rod as large as a lead pencil, rarely as thick as one's little finger, or as a nodule projecting from an area less firm. In other cases when deeply placed and with a thick abdominal wall such palpation will be quite impossible. A certain number

f surgeons allege that in a large proportion of cases they are able to palpate he appendix even when quite deeply placed, and but little if any changed in ize and consistence. Although my experience has not been small, I have never been able to acquire the skill and delicacy of tactile sensibility necessary to feel the normal appendix at all, except under very favorable conditions. The remainder of the abdomen is usually not markedly distended and tympanitic in the cases of localized peritonitis or abscess. Percussion over the region of the appendix does not, as a rule, afford very valuable information. If a massive exudate is present around the appendix, dullness, even flatness or modified tympanitic resonance, may be present. But in the majority of instances, unless an abscess is quite large and in contact with an abdominal wall, no very definite information is obtainable by this means. In the more favorable cases in which the inflammation is confined to the appendix itself the acute symptoms may subside in the course of a few days or a week. Tenderness over the region of the appendix may persist for an indefinite time or even until the attack is renewed. If the process results in an abscess the septic symptoms, instead of getting better, will continue to grow worse, as already described under localized peritonitis. A tumor will be formed in the region of the appendix, which will usually continue to increase in size, and since such an abscess is apt to be surrounded by a dense barrier of adhesions, the outlines of the tumor may be very distinctly marked indeed. If not operated upon, the subsequent history of these cases of abscess is quite varied. As already stated, if the abscess be small, cure is even possible without operation, the abscess may become encapsulated, and its contents finally undergo degenerative changes, or absorption, or calcification. Such an event is, however, rare. In some cases the abscess will finally rupture into the general cavity of the peritoneum, and produce one or other of the forms of fatal diffuse peritonitis. In other cases the abscess may rupture into the intestine (the rectum, the cecum, or the ileum), with partial amelioration of the symptoms. In other cases these patients will go on to die of general septicemia or of some local septic process, such as septic pneumonia, septic pleuritis, subphrenic abscess, suppuration of retroperitoneal lymph nodes, abscess of the liver from suppurative inflammation of the portal vein; sometimes from chronic septic poisoning and exhaustion. Only very rarely does an abscess the result of appendicitis rupture spontaneously through the abdominal wall.

4. **Perforative Appendicitis.**—Perforative appendicitis may present several varieties. If the individual has suffered from previous attacks with involvement of the peritoneum, the appendix may have become an extraperitoneal organ, or in certain cases, as already indicated, this condition may be congenital, as in some of the forms of retrocecal appendix. Under these circumstances perforation of the appendix, whether sudden or gradual, will result in a localized abscess, and the history of the case will not differ from the abscesses formed in the cases of suppurative appendicitis without gross perforation. It is to be borne in mind that an intraperitoneal abscess, if thor-

in some cases there will be pain referred to the shoulder or scapula. In ruptures of the right lobe of the liver the blood tends to accumulate upon the right side of the abdomen, sometimes beneath the liver, but usually finding its way as far down as the right iliac fossa. The blood may accumulate in sufficient quantities to cause dullness on percussion in the right flank. There may be diminution or disappearance of liver dullness at once if the stomach or bowel are also ruptured from the presence of free gas between the liver and the diaphragm. Disappearance of liver dullness occurring at a later period may arise from distention of the bowel with gas due to peritoneal irritation or peritonitis. After the first day or later there may be increased liver dullness from swelling of the liver or, as in one case already cited, the liver dullness may be increased from the formation of a hematoma between the liver and the diaphragm shut in by adhesion. In a case which occurred in the service of Dr. Robert Abbe at the Roosevelt Hospital, a little boy was brought into the hospital a week or ten days after he had been run over in the street. He had recovered from the early effects of the injury and was only moderately ill. There was marked increase of liver dullness; the right lobe of the liver could be plainly felt three fingers' breadth below the border of the ribs. Upon separating adhesions between the surface of the liver and the abdominal wall a large cavity was entered lying between the liver and the diaphragm, which contained a quantity of brownish fluid somewhat bile-stained and many large masses of fibrin. A partly healed rupture of the convex surface of the liver was discovered. The child survived.

After ruptures of the liver jaundice may appear after from two to four or more days. It is caused by the absorption of bile from the peritoneum. It is present in only about twenty per cent of the cases. After ruptures of the gall-bladder or biliary passages it is much more common. Jaundice appearing at a later period will usually be due to abscess of the liver. In many cases it will be impossible to make a certain diagnosis of subcutaneous rupture of the liver. The history of a fall or of some blow or crushing injury of the abdomen without any external signs to locate the seat of the lesion in some particular region, the occurrence of shock, general symptoms of hemorrhage, abdominal pain, vomiting, and hiccough are common to all serious intra-abdominal injuries. In many cases the surgeon will open the belly with the diagnosis merely of abdominal hemorrhage or probable injury of some viscus. Moreover, ruptures of the liver of small extent are no doubt present after severe contusions of the abdomen in many cases which recover without operation. Infection of the effused blood and bile may take place from the organisms supposedly present in the portal circulation, more frequently, it is believed, from organisms present in the biliary passages. Such infection may lead to peritonitis, which often comes on slowly and insidiously after the lapse of many days. In other cases, the irritating effect of the bile and blood upon the peritoneum produces chronic adhesive peritonitis.

The following history of recovery after rupture of the liver, kidney, and

lung illustrates that, if operated upon immediately, a patient may survive a complication of very serious injuries, and further, that ether acts as a heart stimulant in shock, and that if the hemorrhage can be controlled, the intravenous hot saline infusion is an invaluable measure. The history is that of a boy, aged seven years, upon whom I operated in the Roosevelt Hospital on April 14, 1899:

Shortly before, while playing in the street, he had been knocked down by a heavy wagon, one or more of the wheels of which had passed across the middle of his body. Upon admission he was suffering from a marked degree of shock. His skin was cold and bathed in a clammy sweat; he was pale; his pulse was rapid and weak, and his respiration superficial. He vomited occasionally small quantities of clotted blood and mucus. There were no wounds of the skin, except two abrasions upon the right side of the thorax, near the clavicle. The abdomen was distended moderately, uniformly tender, and gave the signs of free fluid in the abdominal cavity. He appeared to be in a dying condition, and was stimulated by means of whisky and strychnin hypodermically.

At 6.30 P.M. a median abdominal incision was made from the ensiform cartilage to the umbilicus. Upon opening the peritoneum considerable fluid blood, together with numerous small fragments of liver tissue, escaped. The alimentary canal was inspected throughout; no rupture was found.

Blood appeared to be flowing from between the upper surface of the right lobe of the liver and the diaphragm.

Examination of the right kidney revealed a transverse rupture of the organ, which appeared to extend nearly through its entire substance.

The peritoneum in front of the kidney was not torn, and the hematoma was so small as scarcely to be noticeable. The spleen and the left kidney were not injured.

The hand was introduced between the liver and the diaphragm; a ragged tear was felt in the right border of the right lobe of the liver, not far from the posterior surface of the organ. The suspensory ligament of the liver was then partly divided, and the anterior border of the right lobe was depressed.

It could then be seen that the right lobe of the liver had been torn away from its posterior attachment to the diaphragm, leaving the extreme right portion of the right lobe still attached. The fissure between the two portions of the liver gaped widely. The edges of the fissure were extensively pulpified. The bleeding had almost ceased. The peritoneal cavity was thoroughly flushed with hot normal salt solution, and dried with pads of gauze. The right border of the fissure in the liver was lightly packed with sterile gauze, which was led out over the upper surface of the liver through the abdominal wound. The liver was then pushed back into place and held there by a large wedge of sterile gauze pressed against its posterior border and lower surface. At this time the patient was in a condition of collapse, which was, however, relieved by an intravenous infusion of 1,000 c.c. of saline solution at a temperature of 118° F.

Upon the following day the entire right side of the patient's thorax was the seat of subcutaneous emphysema. Careful search failed to reveal a fractured rib.

He coughed and expectorated small amounts of bright fluid and clotted blood from time to time.

He remained exceedingly weak, and was nourished chiefly by nutrient enemata for the first seventy-two hours. For three days his urine contained a moderate amount of blood. His temperature was moderately elevated for several weeks, and his pulse remained rapid, not becoming as slow as 120 until the tenth day.

Considerable oozing of blood persisted for several days into the dressings, which was followed by a bright yellow, thin discharge, profuse in amount, and suggesting eggnog in appearance. This resemblance was so marked that the child believed that the eggnog which he drank escaped immediately through the wound. It was thought possible that an opening might exist in the esophagus at its junction with the stomach, but methyl-blue solution administered by mouth did not appear in the wound.

Microscopic examination showed the discharge to consist of disintegrated liver tissue and pus, and chemical tests showed the presence of bile.

The convalescence of this patient was very slowly established. He remained delirious or semiunconscious and apathetic for nearly one month; the large, deep cavity continued to discharge freely, and diminished in size very slowly indeed. He was not in an afebrile condition until the middle of May, or one month after the injury. It was two months before the wound of the abdomen was entirely healed. He remained in bed until the end of six weeks, after which his nutrition improved rapidly, and he left the hospital August 6th, 114 days after the injury, well nourished and physically active, with a comparatively small and firm abdominal scar.

Open Wounds of the Liver.—Incised and stab wounds of the liver can sometimes be diagnosticated from the situation of the wound. The history of the length and character of the blade used and the direction of the stroke may aid in the diagnosis. The general symptoms of open wounds of the liver do not materially differ from those in subcutaneous injuries except that shock is less apt to be present. Hemorrhage is usually free, and if the external wound is of some size there may be rapid external bleeding. The following case history will serve to indicate the conditions in an average case of stab wound of the liver. I operated upon this patient in the Roosevelt Hospital in January, 1900:

He was a young Italian man, twenty-one years of age. Shortly before admission to the hospital, while helping home a drunken male relative, this person drew a dagger and stabbed him in the abdomen. He was picked up by the ambulance and brought at once to the hospital. Upon admission his general condition was good. He had not vomited blood; he had some shortness of breath and considerable pain in the abdomen. Upon examination a wound was found, one inch in length, one inch below the tip of the tenth rib. There was considerable bleeding from this wound, and protruding was a mass of omentum which hung out a distance of several inches. Percussion of the thorax and abdomen yielded no abnormal signs. The respirations were 28 per minute; he was restless; temperature 99° F., pulse 70. The urine was normal. The patient was taken immediately to the operating room and etherized. The original wound was enlarged on a line parallel with the ribs to a distance of five inches.

Upon inspecting the cavity of the belly a moderate quantity of free blood was found. The prolapsed omentum was tied off and removed. There was no wound of the intestine, gall-bladder, nor of the under surface of the liver. At this time it was noted that blood was flowing freely from the upper surface of the liver, and a finger introduced between the liver and the diaphragm readily detected a considerable wound in the upper surface of the former, from which blood continued to escape rapidly. The original incision was extended vertically along the outer border of the right rectus muscle a distance of two inches. The ribs were then drawn powerfully upward and the liver depressed, when a wound was seen in the upper surface of the liver, beginning about an inch from its free border and extending upward, outward, and backward, a distance of three inches. This wound appeared to be about one and a half inches in depth. Upon exploring it with the finger the bleeding increased to an alarming degree. The cavity was hastily packed with sterile gauze, which being gradually removed, the wound was closed with five deep sutures of thick catgut passed through the substance of the organ. Upon tying the last suture the bleeding ceased absolutely. The viscera in the neighborhood of the wound were then carefully washed with hot salt solution, and the wound in the abdominal wall was closed by suture with catgut of the several layers, the skin was closed by silk. A single strand of sterile gauze was led from the site of the wound in the liver through the original stab wound in the abdominal wall. The patient suffered no shock from the operation. The healing of the wound was interrupted by slight superficial suppuration, confined to the neighborhood of the original injury. . . . Six weeks after the date of the injury the patient was enjoying ordinary health. Transitory glycosuria was noted on the day following the operation, which disappeared after forty-eight hours.

I operated successfully for a stab wound of the liver in a second case in January, 1908. The patient's history was as follows:

The patient was a man, aged twenty-five years, a native of Spain. During a drunken brawl he was twice stabbed in the right side of the abdomen with a sharp dagger, the blade of which was about five inches in length and sharp on both edges. He was brought to the hospital soon afterwards by the ambulance. He was not suffering from marked shock. His abdomen was flat and rigid. There was an incised wound of the right side of the abdominal wall, situated two and a half inches below the right costal margin and two inches from the median line, extending horizontally outward one and a half inch. This wound divided the rectus for about half its width, and through it the surface of the low-placed right lobe of the liver was visible. One inch below the navel and one inch to the right was a second incised wound, similar in character to the first. The upper wound bled freely. The patient was operated upon at once. A five-inch vertical incision was made, including the two stab wounds. There was much free blood in the abdominal cavity. The only intra-abdominal injury discovered was a transverse incised wound one and a half inch long, extending upward and backward to a depth of three and a half inches into the right lobe of the liver. The liver in this case was displaced downward so that its free border was on the level of the navel. The wound in the liver substance bled freely. The hemorrhage was stopped by a deeply placed mattress suture of chromic gut. The abdominal cavity was washed free

from blood. The lower stab wound had not injured the intestine, much to my surprise. The abdominal wound was closed by sutures, with drainage for the stab wounds in the abdominal wall. The patient made a good recovery.

Gunshot Wounds of the Liver.—If the wound of entrance is in such a position as to make a wound of the liver possible, a knowledge of the direction from which the shot was fired may aid in the diagnosis. If there be also a wound of exit, perforation of the liver may be inferred, notably if the signs of intra-abdominal hemorrhage and shock are marked. In the absence of these general symptoms we should be cautious in drawing such an inference, especially if the wound has been made by a low-powered pistol. If, on the other hand, a high-powered military rifle has produced the wound, fired at an ordinary range, it is safe to infer that the bullet has pursued a straight course through the body. As already stated, hemorrhage from gunshot wounds of the liver substance is commonly less marked than after incised wounds and ruptures. This will, of course, be modified if the portal vein or one of its larger branches is injured. Some differences exist in the effects upon liver substance of pistol bullets, soft-lead rifle bullets, and jacketed military rifle bullets. The first cut grooves or channels through the substance of the liver without, as a rule, producing extensive and widespread laceration. The second, when fired at short ranges, produce widespread laceration of tissue, and frequently severe hemorrhage with marked shock. Such wounds made during the Civil War in the United States were commonly speedily fatal. In using sporting rifles with a soft-lead bullet of large caliber in deer hunting, I have several times observed that if the bullet passed through the liver the animal frequently fell to the ground at once, or fell after running a very short distance. Very extensive destruction of liver tissue was present in these cases, and if the portal vein was wounded, or one of its larger branches, there was immediate and large intra-abdominal bleeding. Several of my friends tell me that they have made similar observations. The modern military rifle bullet appears to be capable in some cases of passing through the liver without doing material damage, making a round perforation, and a great many soldiers shot through the liver in this way have survived without serious symptoms and without operative treatment. Under other conditions—probably of short range, possibly of ricochet shots or of an upset bullet—explosive action and extensive destruction of liver tissue is sometimes observed. Such cases do not come under surgical treatment. As illustrating the effect of a pistol bullet upon the liver, I give briefly the history of a case operated upon by Dr. Charles McBurney in the Roosevelt Hospital, some years ago, at which I assisted:

A boy, aged fourteen, accidentally shot himself in the epigastrium with a .41 caliber pistol loaded with only a small charge of black powder. He was brought to the hospital with the symptoms of shock and the signs of intra-abdominal bleeding, abdominal pain, tenderness, rigidity. His abdomen was opened in less than an hour after the shooting. There was much free blood in the peritoneal cavity

one of the hollow viscera were wounded. There was a furrow three inches in ngth, a half inch deep at its deepest part, and about a half inch or more in idth, extending from before backward upon the upper surface of the left lobe of he liver. This wound bled only moderately. There was a wound of the left crus of the diaphragm which bled freely and was evidently the main source of hemorrhage. This wound was closed with gauze packing and the bleeding stopped. The abdomen was cleansed and the wound in the abdominal wall closed with sutures except at its upper angle, which was left open for the emergence of the gauze. Uninterrupted recovery. In the subsequent history of wounds of the liver, whether subcutaneous or open, infection of the liver tissue and abscess of the liver, subphrenic abscess, septic pleuritis, sometimes peritonitis, are the complications to be feared.

INJURIES OF THE BILIARY PASSAGES

Such may be subcutaneous ruptures or open wounds—i. e., stab or gunshot wounds, or intentional or accidental wounds produced by the surgeon during operations upon the gall-bladder or upon the gall-ducts. Assuming that the biliary passages are in a healthy condition, the escape of bile into the free cavity of the peritoneum is followed by a sero-fibrinous or, later, adhesive peritonitis rather than by purulent peritonitis. In other words, bile may accumulate in the peritoneal cavity in large quantities without producing fatal results. Certain conditions predispose to rupture of the gall-bladder. A distended gall-bladder, the cystic duct being plugged by a stone or the seat of cancerous disease, or a gall-bladder whose walls are friable from acute inflammation, is more likely to rupture from slight degrees of violence than is a healthy nondistended gall-bladder. The symptoms and signs of rupture of the gall-bladder from subcutaneous injuries do not materially differ from those of rupture of the liver, except that in uncomplicated cases the signs and symptoms of severe intra-abdominal bleeding are either absent or less marked. There will be a history of a blow or a fall upon the region of the gall-bladder; the patient will be seized with severe abdominal pain, referred to the right upper quadrant of the abdomen; he will usually vomit; there will be localized tenderness and rigidity beneath the right costal border. The symptoms of shock will be more or less marked. If not operated upon, the bile will accumulate in the cavity of the peritoneum. As the days go by, assuming that the patient does not die of associated injuries, the abdomen will become more and more distended with bile or a combination of bile with blood-stained serous fluid. There will be moderate abdominal pain and tenderness. If the patient is not already the subject of a chronic adhesive peritonitis, he will at the end of a few days become jaundiced. If the rupture has affected the common bile duct, and not the gall-bladder, there may be clay-colored stools. If the patient was suffering from an infectious cholangitis at the time the rupture occurred, instead of the signs and symptoms as recorded, he will develop a diffuse purulent peritonitis. In the case of open wounds involving the gall-bladder or gall-ducts there may be the immediate escape from the external wound of bile

or of bile mixed with blood. This sign indicates a wound of the biliary passages rather than a wound of the liver, since in wounds of the liver the discharge does not contain appreciable quantities of bile for a number of days. It often happens that wounds and ruptures of the biliary passages are accompanied by serious associated injuries of the liver, the duodenum, the pancreas, the kidney, the stomach; in these cases the signs and symptoms of rupture of the biliary passages may well be obscured. Should the diagnosis of rupture of the biliary passages be made, the surgical indications are to close the wounded gall-bladder or ducts by suture, to remove the bile from the cavity of the peritoneum, and to provide drainage in case the wound in the bladder or duct cannot be closed or continues to leak. The experiences of William J. and Charles H. Mayo in their operations upon the biliary passages (*Annals of Surgery*, July, 1905) are, that not only the division, but actual loss, of substance in the common bile duct is capable of repair and complete reëstablishment of function. In one or more cases the ends of the duct were approximated as nearly as possible by fine catgut sutures passed through the surrounding structures and through the divided ends of the bile duct, including all its coats. In one case a permanent communication was successfully established between the end of the hepatic duct and the duodenum. Adequate provision for drainage should, of course, be made in these cases.

ABSCESS OF THE LIVER

The classical form of abscess of the liver, the so-called tropical liver abscess, is very commonly associated with amebic dysentery. The disease occurs especially among persons who, having lived their lives in an ordinary temperate climate, reside for a period of years in tropical countries, and who continue to indulge in alcohol, in an abundant meat diet, or who, in other words, do not adapt themselves in their diet and mode of life to their environment. Just how much influence the conduct of their lives has upon the production of liver abscess among such people it is hard to say. Usually the formation of a liver abscess has been preceded by an attack of dysentery. The frequency with which dysentery may be demonstrated as a cause for an amebic abscess of the liver varies somewhat in the statistics of different observers: Kelsch and Kiener in seventy-five per cent, Warnig in only 27.3 per cent of the cases. Certain it is that abscess of the liver much more frequently follows dysenteries acquired in a tropical climate than in a temperate one, and yet such cases do occur in the vicinity of New York among people who have never been in a tropical country. In some of these cases the ameba may be demonstrated in the stools or in the pus found in the liver. In some the ameba is absent and the pus is sterile. These conditions are also true of the distinctly tropical abscesses. In other cases of tropical abscess the ameba will be found together with one or other of the pus-producing bacteria found in the intestine—the Bacillus coli, the streptococcus, one or other of the varieties of staphylococcus

occasionally the pneumococcus. The frequency with which amebic dysentery is followed by abscess varies also in the statistics collected in different countries. For example, the annual report of the sanitary commissioner with the Government of India for 1894 shows that thirty-five per cent of European soldiers who die from dysentery in India had pus in the liver. Thomas L. Rhoads, medical department, United States army ("The Diagnosis of Abscess of the Liver," *Annals of Surgery*, May, 1904), states that during a period of over two years he found that liver abscess occurred in slightly less than five per cent of dysentery patients among the American soldiers in the Philippine Islands, and further, that a similar result was arrived at by Dr. Craig at the Army General Hospital, Presidio of San Francisco, the principal receiving hospital in the United States for patients from the various military hospitals in the Philippines. His observations extended over a period of five years. Dr. Rhoads believes, from an extensive experience, that all cases of amebic abscess of the liver have been preceded by a dysenteric ulceration of the bowel, and that in those cases where no such causal relation can be established by the history of the case, the symptoms have either been slight or forgotten by the patient, or that, as is quite possible, the dysenteric ulcerations were small in size and ran a latent course, producing no symptoms.

In addition to dysenteric liver abscess, suppurative inflammation of the liver may occur under a great variety of conditions. As already noted, traumatisms, whether contusions or open wounds, may be followed by liver abscess. Further, in the course of any of the severe infectious fevers, notably typhoid, occasionally from the entrance of lumbricoid worms into the biliary passages, from echinococcus infection of the liver, rarely from tuberculosis, actinomycosis, and gumma of the liver. Further, from suppuration in the biliary passages, from gall-stones or other cause. Further, as a direct extension of perforating ulcers of the stomach or duodenum, and, as already indicated, as the result of a septic thrombophlebitis of the mesenteric veins due to infectious lesions of the intestine, most often to appendicitis. It is believed by many surgeons that multiple pyemic abscesses of the liver occurring, as they do occasionally, without evident cause, are due in a large proportion of cases to unrecognized disease of the vermiform appendix, usually in the nature of minute ulcerations of the mucous membrane of the appendix of so trifling a character as to produce no definite symptoms. It is a well-recognized fact that liver infections may follow attacks of appendicitis and operations for appendicitis weeks and months after the patient is apparently entirely cured. Attention has been especially directed to these types of infection of the liver following appendicitis by Dr. John C. Munro, of Boston (*Annals of Surgery*, November, 1905). Additional and not very infrequent causes of liver abscess are suppurations in the vicinity of the rectum, ischiorectal abscess, operations upon hemorrhoids, ulcerating carcinoma of the rectum, etc. Pneumonias, gangrene of the lung, inflammations in the mediastinum, and pyemic processes, wherever situated, are not infrequently accompanied by metastatic liver abscess.

These occasional causes of liver abscess are in general less frequent and less interesting from a surgical point of view than those following dysentery. In the pyemic forms and in those following appendicitis the abscesses of the liver are usually multiple; the process is frequently a terminal one, and is only too often not in any way amenable to surgical treatment.

Diagnosis of Tropical Liver Abscess—Amebic Abscess—Abscess of the Liver following Dysentery.—Dr. Rhoads's article on the diagnosis of liver abscess is based upon such careful observations, so large an experience, and is so admirably expressed, that I have utilized the information therein contained to a considerable extent. In typical cases of tropical liver abscess the essential features are as follows: The patient gives a history of dysentery contracted in a tropical country. The dysentery may be cured; he may have from time to time slight and transient outbreaks of dysenteric symptoms; he may at the time be suffering from the symptoms of chronic dysentery. The patient has lost weight, the expression of his face is sad, anxious, and drawn. The color of his skin is an ashen brown. The eyes are dull, the sclera have a yellowish tinge, and yet not the yellow of jaundice. He complains of muscular weakness, his movements are languid and slow. He has a sense of weight, of fullness, or of dragging pain in the region of the liver. If he is lying down he lies upon his back, turned a little toward the right, his extremities are flexed to diminish as far as possible the tension of the abdominal muscles over the right lobe of the liver. The liver dullness is increased in one of the ways presently to be described. There is an area of tenderness more or less marked somewhere over the right lobe of the liver. If the abscess has penetrated the liver and involved the abdominal or thoracic wall there may be an area of edema. If the infection is purely of the amebic type his temperature will be normal in the morning, there will be a slight evening rise of 99.5° or 100° F. If the infection be a mixed one, partly due to pyogenic bacteria, the morning temperature may be normal or a little elevated, the evening temperature may rise to 102° or 103° F. The pulse undergoes a corresponding acceleration, it will be normal in the morning, and with the evening rise of temperature will be 100 or 110. A slight or moderate leucocytosis may be present with a moderate relative increase of polynuclear cells. There is usually a moderate grade of anemia. The bowels may be constipated, or if the dysentery remains uncured, there will be more or less characteristic diarrhea. The tongue is coated. The patient may suffer from chilly sensations, but has no chills. In the absence of complications the patient is not jaundiced. The skin is moist.

Signs and Symptoms of Tropical Liver Abscess in Detail.—In a case giving such a history as the preceding, and presenting such signs and symptoms, the presence of the ameba of dysentery in the stools is strong confirmative evidence of liver abscess. It is to be remembered, however, that in a pretty large proportion of cases, according to Rouis in fully thirty-three per cent, the course of liver abscess is entirely latent, the symptoms are hidden by those of the dysentery, or of pyemia, if such be present, until the time when the abscess

suddenly ruptures into the colon, into the stomach, into the lungs, or into the peritoneal cavity, the pericardium, the pleura, into the vena cava, or elsewhere. In a good many cases, as may be readily understood, the immediate result of the rupture is the rapid or even sudden death of the individual. The most favorable point of rupture is into the lungs, with the evacuation of the abscess through the bronchi. Spontaneous cure is possible in this event in a small proportion of cases. The next most favorable point of rupture is into the colon. Spontaneous healing is here also possible, although very rare. Tropical abscesses of the liver are solitary, as a rule, those proceeding from ordinary pyemic processes and from appendicitis are usually multiple. Tropical abscesses occur more often upon the convex surface of the liver than upon the concave under surface. Not infrequently they occupy a position near the free border of the liver. They are much more common in the right than in the left lobe. In cases not very far advanced, the physical signs of enlargement of the liver may be present or absent. An increase in size of the liver is to be appreciated by the ordinary means of percussion, palpation, sometimes inspection. By percussion it will usually be possible to make out a moderate or considerable increase of liver dullness both upward and downward. The increase in dullness in a vertical direction will usually be most marked between the mammillary and anterior axillary line. In a considerable proportion of cases the liver dullness will extend well below the costal border. In these cases the lower border of the liver can usually be palpated, as described under the Diagnosis of Diseases of the Abdomen. If the patient is much emaciated, and if the abscess is situated upon the concave surface of the liver, it will sometimes be possible to depress the abdominal wall sufficiently, so that the fingers are able to detect a projecting mass on the under surface of the liver. If the abscess has reached the peritoneal covering of the liver and produced a localized peritonitis, there will be pain, tenderness, and rigidity on palpation below the costal border. Dullness in the epigastrium to the left of the median line, together with localized pain, tenderness, and rigidity, indicates that the abscess is situated in the left lobe of the liver. If the abscess has reached a large size, there will be immobility of the ribs upon the right side, and often a distinct bulging of the thorax over the lower ribs.

Pain.—According to Rouis and Chvostek, spontaneous pain may be absent in from fifteen to twenty-eight per cent of the cases. In most cases the patient will complain of a dragging sensation of discomfort, and even of actual pain somewhere over the right lobe of the liver, and in some of the cases the pain will be referred very nearly to the actual situation of the abscess, so that the patient's subjective sensations may be a valuable guide. In advanced cases when the abscess has reached the surface of the organ there will often be sharp stabbing pains due to peritoneal irritation. These pains may be referred to the under surface of the liver in front or to a point beneath the lower ribs behind. When present such pains are again a diagnostic sign of considerable value. If a point of greatest localized tenderness on pressure corresponds with

the seat of the pain, the value of the sign is greatly increased. It usually indicates the place where the abscess lies nearest to the surface. Pain radiating to the right shoulder is only occasionally present—namely, in those infrequent cases where the abscess is situated on the under surface of the liver near the base of the gall-bladder, in the Spigelian lobe, or near the posterior inferior border of the right lobe of the liver near the transverse fissure (Rhoads).

Temperature and Pulse-rate.—The temperature and pulse-rate are of a mild, moderate, or severely septic type, according to whether the ameba alone is present or is associated with one or other of the pyogenic microbes, and in the latter condition the septic symptoms will vary in intensity, according to the variety and virulence of the particular group of organisms present. That is to say, the temperature is usually higher in the evening, lower in the morning, and the pulse corresponds more or less accurately to the temperature curve. In severely septic cases the pulse-rate will remain notably and continuously accelerated throughout the twenty-four hours.

Leucocytosis.—In the purely amebic cases slight leucocytosis with moderate relative increase in the polynuclear cells was observed by Rhoads in a number of cases. The average of the leucocyte count in these cases was 12,500. In cases of pyogenic infection the leucocyte count will vary in the ways already indicated under Inflammatory Leucocytosis.

Dilatation of Blood-vessels.—Dysenteric abscess of the liver, even though the abscess be of small or moderate size, is quite commonly accompanied by visible dilatation of the subcutaneous veins of the upper portion of the abdomen and lower portion of the thorax upon the right side, due to the interference with the portal circulation of the liver by the pressure of the abscess and the inflammatory swelling of the liver substance in general.

Jaundice.—Jaundice is not one of the regular accompaniments of amebic abscess of the liver. It will not be present unless the abscess presses upon some of the larger branches of the hepatic duct, or unless there be a coëxistent cholangitis.

The Urine.—The urine in the amebic abscess of the liver regularly contains a small quantity of albumen. If the abscess is due also to pyogenic infection, a septic nephritis will be present of a more or less marked grade, according to the intensity of the infection.

The Spleen.—The spleen is not enlarged in amebic abscess of the liver, and in cases where the abscess is central and is attended by marked general enlargement of the liver this absence of a splenic tumor may serve to distinguish the disease from malarial fevers, possibly from typhoid, and from the various forms of anemia accompanied by enlargement of the spleen.

Other Signs.—If the abscess has approached the convex surface of the liver, and has caused a localized peritonitis, but has not formed adhesions between the liver and the diaphragm, friction sounds may sometimes be heard or even felt upon deep inspiration by auscultation or palpation over the right lobe of the liver. When the abscess has reached a considerable size and occu-

pies or originates in the posterior portion of the right lobe, bulging of the wall of the thorax may be quite evident. The shape of the thorax will be bell-shaped rather than barrel-shaped, and this may serve to distinguish the condition from a purulent pleuritic effusion. If the abscess attains a large size and has become adherent to the diaphragm the patient will suffer from dyspnea. If the abscess is in the left lobe of the liver, pressure upon the heart or invasion of the pericardium may also produce dyspnea and a rapid action of the heart. If the abscess involves the diaphragm there may be pleuritic friction sounds and a dry cough. If the lung becomes adherent to the diaphragmatic pleura the abscess may evacuate itself through the lung, and the rupture will be accompanied by cough and the expectoration of large quantities of brownish, blood-stained, chocolate-colored pus. Localized edema of the chest wall or of the abdominal wall below the costal border, accompanied by tenderness, indicates that the abscess has become adherent to and is invading the overlying tissues. Under these conditions the liver ceases to move with respiration. Digestive disturbances more or less marked are a regular accompaniment of abscess of the liver. The patient has no appetite, his tongue is coated with a grayish fur; it is not the dry, brown, and coated tongue of typhoid fever, nor is the tongue swollen and indented by the teeth, as is the case in chronic malarial poisoning. Nausea and vomiting are not common symptoms; if the patient has recovered from his dysentery, he will usually be constipated and will suffer from flatulence of the bowels.

Among the diagnostic signs are chilly sensations, regularly present from time to time in cases of amebic abscess. Actual chills are rare. If pyogenic germs are present, chills may occur as the result of the invasion of new regions, as, for example, when the abscess ruptures into the pleura or into the lung, or into some other organ or cavity. When the abscess is situated in the left lobe of the liver, there may be difficulty in swallowing from pressure upon the cardiac end of the esophagus. While the presence of the ameba in the stools is confirmatory of amebic abscess of the liver, the absence of the ameba signifies nothing. When the abscess has approached and commenced to perforate the anterior abdominal wall, the sign of fluctuation may be present. It is a different kind of fluctuation from that observed in an echinococcus cyst of the liver. Fluctuation over an ordinary abscess of the liver, when appreciable, gives a sensation to the examining fingers of fluid in a sac under but little tension; echinococcus cyst, on the other hand, gives the sensation of fluid in a sac under very considerable tension. In some cases an echinococcus cyst may even feel like a solid tumor, the tension of the sac being so great that the sign of fluctuation cannot be appreciated. When the signs indicate that the abscess lies in the posterior portion of the right lobe of the liver or between the liver and the diaphragm, or if the question arises as to whether the pus is in the pleura, in the liver, or in the subdiaphragmatic space, it is permissible to introduce an aspirating needle with all due antiseptic precautions. The information gained by this means has already been indicated in discussing the diag-

nosis of subphrenic abscess. If the abscess presents in front, in the epigastrium, or along the right costal border, and if the abdominal wall is not already infiltrated, so that the surgeon is sure that the general cavity of the peritoneum is closed off, no needle should be introduced. The danger of infecting the peritoneal cavity is imminent. An aseptic abdominal incision is the safest diagnostic measure. The signs and symptoms of perforation of liver abscess into the various hollow organs of the abdomen, or in other directions, cannot for want of space be discussed in this place. In a general way the patient will usually suddenly become more ill, will have decided septic symptoms, and will develop some new train of localized symptoms more or less characteristic. It is further necessary to differentiate abscess of the liver in certain cases from diseases of the biliary passages, from cystic conditions of the kidney, whether inflammatory or not, from cyst of the pancreas, and some other conditions. The history of the case, as well as general and local signs and symptoms pointing to disease of special organs, will usually be sufficient for a differential diagnosis. (See Diseases of the Gall-bladder, Kidney, and Pancreas.)

ECHINOCOCCUS CYST OF THE LIVER

Of all the tissues of the body the liver is the most frequent site of echinococcus. Most commonly the condition develops as one single focus in the liver tissue. In rare cases disseminated foci are formed in the liver. The former group of cases alone are of surgical interest. The history, pathology, and general character of echinococcus disease have been sufficiently described in the section upon this topic. (See General Surgery.) In regard to the occurrence of the disease in the liver, it may be said that in all but ten or twelve per cent of the cases a solitary cyst is developed, usually in the right lobe of the liver. The liver is increased in size in various ways, according to the site of the cyst. If the cyst is central and does not reach the surface of the liver, the liver may be increased in size without much change in its shape. If the cyst develops near the free border of the liver, or upon its under surface, or if there are multiple cysts, the size of the liver and its shape may both be altered in a more or less variable and irregular manner. Those cysts which develop near the upper surface of the liver will press the diaphragm upward, and may seriously interfere with the function of the right lung. The lung may be even so far compressed as to entirely cease to functionate. If the cyst develops upon the lower surface of the liver it will grow downward, and may more or less completely fill the abdominal cavity. By pressure upon the liver substance the liver tissue overlying the cyst gradually undergoes atrophy. Jaundice is only occasionally produced by pressure upon the biliary passages. Several accidents may happen during the existence of echinococcus cyst of the liver. The cyst may be ruptured by external violence in one of several directions. It may become infected with pyogenic microbes and undergo suppuration. The worm may die and cease to grow, the cyst may undergo atrophy and spon-

taneous cure, its contents being changed into material resembling that found in a sebaceous cyst or its contents may become calcified. Pressure upon the inferior vena cava may produce ascites. If the cyst is ruptured by trauma, or spontaneously perforates by pressure into the lung, the cysts may be coughed up and partly evacuated. Such a rupture is attended by the danger of asphyxia. Rupture into the general cavity of the peritoneum may result in severe systemic poisoning from the absorption of toxic products in the nature of ptomains contained in the cystic fluid. Such ruptures are always followed by a characteristic outbreak of urticaria upon the skin, and this symptom is of considerable diagnostic value. If the cyst is alive, rupture into the peritoneal cavity may be accompanied by disseminated echinococcus of the peritoneum. If the cyst is already infected with pyogenic germs, rupture into the peritoneal cavity will be followed by fatal peritonitis. The cyst may rupture into any portion of the alimentary canal, or into the urinary passages, rarely outwardly by perforation of the abdominal wall. Perforation into any of the large blood-vessels of the abdomen is also possible; and if the cyst is in a condition of suppuration, such perforation will be followed by pyemia. Rupture into the biliary passages may be followed by one of two results: If noninfected bile gains access to the cyst in considerable quantity, the life of the worm will be destroyed, and thus spontaneous cure may occur. If the bile is infected, suppuration of the cyst will result. As already noted, echinococcus is a rare disease in the United States. Only a few cases are observed each year in the various hospitals of the city of New York. The patient with echinococcus cyst of the liver, whose picture appears in the text, was a patient in the New

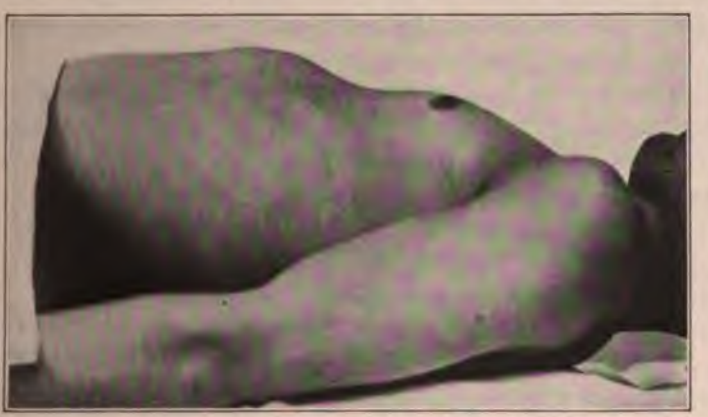


FIG. 24.—ECHINOCOCCUS CYST OF THE LIVER. (New York Hospital, service of Dr. Frank Hartley.)

York Hospital under the care of Dr. Frank Hartley. During the ten years that I worked in the Roosevelt Hospital only a very few cases occurred. During the past ten years five or six cases only have been observed in the New York Hospital.

The worm once having made its home in the liver, the duration of the dis-

ease is variable. In general its progress is exceedingly slow. Its duration is placed by various authors as between two and thirty years, and several observers who have seen many cases believe that when echinococcus of the liver appears during adult life it has frequently been acquired during childhood. The course of the disease varies also a good deal, according to whether rupture takes place into the peritoneal cavity. Such rupture is followed by immediate death in ninety per cent of the cases. Rupture through the abdominal wall is attended by a mortality of ten per cent (Cyr).

Symptoms.—Generally speaking, echinococcus cyst which forms in the central portion of the right lobe of the liver produces no symptoms at all for a long time. When the tumor has attained such a size that it begins to interfere with the functions of other organs by pressure, then certain symptoms will be developed, due partly to mechanical causes, and these symptoms will vary according to the organs or structures which are compressed. The most striking symptoms are produced when, as not infrequently happens, the cyst becomes infected with pyogenic germs. The patient will then become more or less profoundly septic; he will suffer from loss of flesh and strength with fever, with abdominal pain and tenderness combined with the symptoms of pressure upon the surrounding organs. If the cyst grows upward toward the pleural cavity, so that the heart or the right lung, or both, are seriously compressed, the patient will suffer from dyspnea, from irregular action of the heart, and sometimes from a cough. If the cyst grows downward and compresses the kidney or the ureter the patient may suffer from albuminuria, possibly from pressure upon the ureter, from hydronephrosis. In addition, perforation in one of many directions is one of the probabilities of the later stages of the disease. Some of the possible results of such perforation have already been indicated. Further, it may be said that perforation into the pleura direct is usually fatal. That perforation into the lung may be followed by chronic or septic pneumonia, sometimes by sudden asphyxia. Perforation into the stomach or intestine may be followed by the passage of cysts *per rectum*, or they may be vomited; there will also be the signs of circumscribed peritonitis more or less marked. Perforation into the urinary passages is sometimes followed by blocking of the ureter, or of the internal orifice of the urethra. When the cyst has grown to such a size that it forms a palpable tumor in the abdomen the following characters may be noted: The tumor is evidently connected with the liver; its surface is smooth; in shape it is more or less globular, and gives the sensation to the examining hands of a tense fluctuating tumor. The sign so commonly described as being characteristic of echinococcus cyst of the liver—namely, the peculiar jellylike vibration transmitted to the fingers when the cyst is lightly tapped or pushed from side to side—is absent in a large proportion of cases. Thus, for example, Finsen, who had examined two hundred and thirty-five cases, was unable to detect this sign in any of them. The cystlike character of the tumor even may not be recognized on palpation, the wall of the cyst may be thick and firm, and may contain fluid under such tension that

the mass feels like a solid tumor. Upon percussion the cyst gives absolute flatness. If no inflammatory adhesions exist to the surrounding structures the cyst will move with respiration with the liver. Although the diagnosis of echinococcus cyst of the liver can usually be made with certainty by the use of an aspirating needle from the physical and chemical characters of the fluid, and from the presence of the hooklets as seen under the microscope, yet this means of diagnosis is generally not permissible. The dangers of the escape of the irritating and poisonous, frequently infectious, cyst contents into the free cavity of the peritoneum are so great that unless the surgeon has his patient upon the operating table and under ether, the introduction of an aspirating needle would be entirely unjustifiable, and under these conditions aspiration offers no advantages over an aseptic abdominal incision, since the treatment of the condition, no matter what the character of the cyst, is purely surgical. As already indicated, the diagnosis of suppuration in the cyst is easy. There will be the history of a chronic, very slowly growing tumor of the liver, which has probably up to that time not seriously interfered with the general health. When the cyst becomes infected the patient will develop the signs of an intra-abdominal inflammation more or less marked, together with those of acute or chronic sepsis. The avenue whereby the surgeon approaches an echinococcus cyst for operation will depend upon the situation of the cyst. If it presents beneath the anterior abdominal wall in front, the incision will be made here. If it has grown backward and upward between the liver and the diaphragm, the resection of one or more ribs, suture of the parietal pleura to the diaphragm, and incision of the diaphragm will be the route followed. The differential diagnosis of echinococcus of the liver from other conditions in this region may be very easy, or in some cases difficult or impossible. Much will depend upon the former history of the case. In cases of abscess of the liver there will be a history of an injury, of dysentery, of gall-stone disease, of appendicitis, or of some one of the other causes already enumerated for liver abscess. Tumors of the kidney or inflammation of the kidney will usually give a history pointing to disease and disturbance of the genito-urinary apparatus, and the tumor, if large and readily palpable, will exhibit the anatomical and physical peculiarities already indicated. An enlarged gall-bladder will, if palpable, usually be readily recognized as such, although cases have been described in which echinococcus cysts formed pendent tumors which could not be distinguished from a gall-bladder. A history pointing to disease of the biliary passages can usually be obtained. The diagnosis of echinococcus of the liver, presenting posteriorly and suppurating, from subphrenic abscess and empyema thoracis can usually be made from the history of the case. The long history of an enlargement of the liver in echinococcus; the causative factors commonly present in subphrenic abscess, an injury, or diseases such as appendicitis, perforative lesions of the stomach and duodenum, acute inflammations of the biliary passages, etc., as described under Subphrenic Abscess. In empyema a pneumonia has often preceded, or the attack has commenced as

a typical acute pleurisy with acute stabbing pain in the side, etc. (see Empyema), or some septic disease, or typhoid fever, or some equally evident causative factor, appendicitis, or an open wound of the pleura. In case of doubt, the introduction of an aspirating needle as described under the diagnosis of subphrenic abscess is permissible, especially if the surgeon is prepared to operate then and there, should pus be present. The characters of the exudates and their situations are sufficiently described elsewhere.

Multilocular Echinococcus.—In this form of the disease a greater or less area of the liver substance is inhabited by numerous small cysts. The process is attended by the production of much new firm connective tissue, so that the tumor formed is very hard. Upon section, this firm stroma is honeycombed with minute cysts; sometimes the central portion of the mass undergoes degeneration and softening. The growth may cause some enlargement, but rarely great deformity of the right lobe of the liver. Should such a condition be met with, the only useful treatment is excision of the entire mass in healthy liver tissue. Should this be impossible, nothing of much value can be accomplished. Amyloid degeneration, hypertrophic cirrhosis, and enlargement of the liver from valvular disease of the heart present concomitant signs and symptoms, such that they are not likely to be confounded with echinococcus. Enlargement of the liver from heart disease may pulsate.

NOTE.—The finer points of distinction between echinococcus multilocularis and the ordinary form call for further investigation; the larval form or multilocular echinococcus is the "gallertkrebs," "alveolar colloid," or "colloid cancer," usually found in the liver and reported, in man, especially for Russia, Bavaria, Switzerland, Würtemberg, Austria, the Alps, and Baden (C. W. Stiles, Osler's "Modern Medicine," vol. i, page 578. Lea Brothers & Co., 1907).

CYSTIC TUMORS OF THE LIVER OTHER THAN ECHINOCOCCUS

A variety of cystic tumors have in rather rare cases been observed in the liver. They are usually slow-growing tumors, which may in time attain considerable or even a large size. They commonly appear near the free border and upon the convex surface of the liver. It will usually be quite impossible to differentiate them from echinococcus before opening the abdomen. The following types of cysts have been reported: General cystic degeneration of the liver with the formation of innumerable cystic cavities in the liver substance, the individual cysts being of small size. When found at operation they are to be let alone; the condition is not exceedingly rare, and resembles and is sometimes associated with a similar condition in the kidney. Small *isolated cysts* are sometimes observed on the surface of the liver. They have no serious significance, and may be let alone. Cavernous angioma of the liver is not very rare; six or more cases have been operated successfully by various surgeons. Dermoid cysts, retention cysts, containing bile. Cysts lined with

ciliated epithelium. Epithelial cysts (cysto-adenoma). Lymph cysts (Leppmann) are occasionally observed.

SOLID TUMORS OF THE LIVER

Gumma of the Liver.—The formation of single or multiple gummata in the liver is a not very uncommon lesion of tertiary syphilis. Diffuse syphilitic hepatitis is without surgical interest. The localized affections occur either as single or multiple gummatous nodules, varying in size from a pea to a hen's egg or a fist, or as bands of syphilitic infiltration extending from the depths of the organ to the surface. While the gummata of the liver frequently undergo necrotic changes, softening and breaking down, such as commonly occurs in the case of external gummata, is rare; condensation of tissue is the rule. A few soft gummata have been found at autopsy. The vicinity of the suspensory ligament of the liver, and of the porta hepatis, and along the course of the branches of the portal vein are the favorite sites, although isolated or multiple gummata may occur along the free border or upon the upper surface of the right lobe. The liver is generally enlarged; in some cases greatly; in others, if the disease is advanced, contraction of the dense new connective tissue, regularly formed as a part of the process, may even cause marked diminution in size. When the affection consists of isolated gummata, a hard, distinctly palpable tumor may be formed. Tillmans removed a gumma from the liver as large as a man's fist with good results. The tumor was removed with the cautery after permitting it to grow fast to the abdominal wound. Before removal it was believed to be a sarcoma. When the process is associated with the production of bands of firm connective tissue running in various directions throughout the substance of the organ, the surface of the liver may be divided into irregular lobules; in some cases a portion of liver tissue may thus be isolated from the remainder of the liver, forming a more or less movable tumor attached to the liver by a bridge of connective tissue. The liver may be divided up into lobulated masses of liver tissue separated by dense cicatricial bundles; the condition has been called botryoid liver, from its supposed resemblance to a bunch of grapes. When the syphilitic process causes pressure upon the portal vein ascites may be present. Jaundice is rarely observed, unless the process is diffuse, resembling, then, in causation the jaundice of cirrhosis. The symptoms and signs of gumma of the liver are rarely so distinctive as to enable one to make a positive diagnosis. The most constant phenomenon other than enlargement of the liver, with the formation of one or more hard, palpable tumors, sensitive on pressure, is *pain*. In the earlier stages pain may be slight or absent, but the formation of contracting bands of connective tissue causing depressions and inequalities of the liver surface, sometimes with a perihepatitis and adhesions to surrounding structures, is regularly accompanied by pain. The pain may be constant, heavy, and dragging, referred to the whole liver region or to a particular part. There may be sudden exacerbations of

pain; usually the patients suffer pretty steady discomfort all the time. Th physical signs do not permit a differentiation from carcinoma of the live notably when the disease occurs during the cancerous age. The picture of young man in the text, showing a nodular enlargement of the liver, was i all probability a case of multiple gummata of the liver. There was a history o acquired syphilis three years before at the time I saw the patient he wa

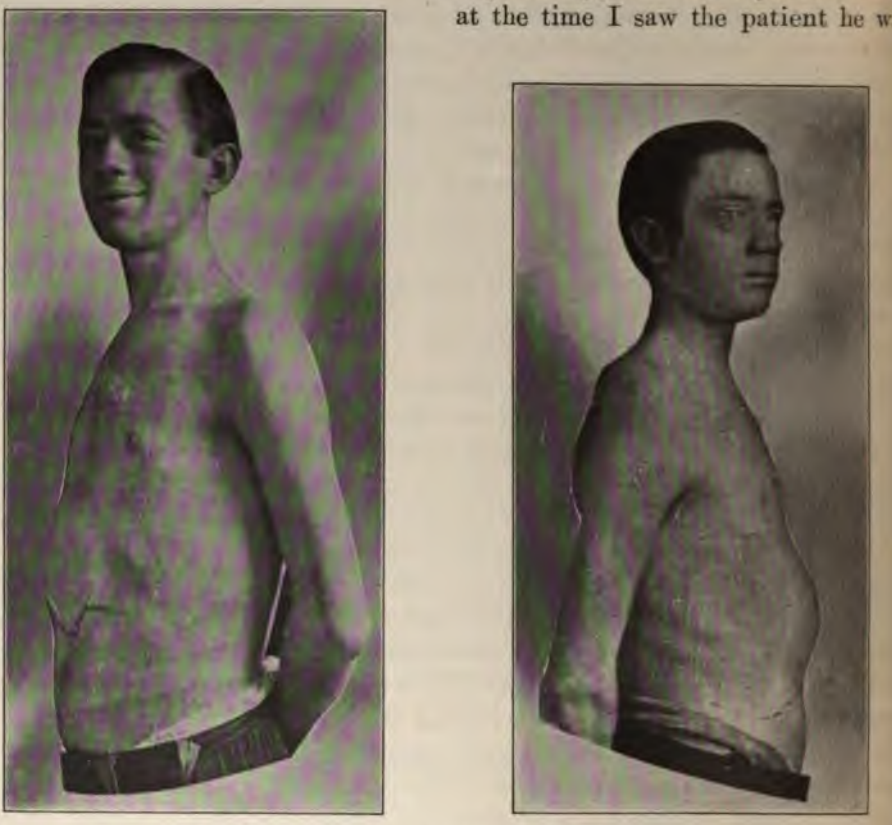


FIG. 25.—GUMMATA IN THE LIVER. (Author's case.)

twenty-one years old. He was not cachectic. He had had a sense of discom fort and dull pain in the liver for six months. The liver was notably enlarged The nodules were hard, rather sensitive on pressure, and felt as large as hens eggs or larger. Under vigorous antisyphilitic treatment the nodules dimin ished rapidly in size, and the pain and discomfort subsided. At the end o three weeks he considered himself well, left the hospital, and withdrew fro observation. When first seen in the later stages of the disease amelioratio of symptoms may be expected from treatment. The destruction of liv tissue is, of course, permanent. In any case when the diagnosis of cancer not positive, it can do no harm and may do good to put the patient up inunctions and KI internally.

The *benign solid tumors of the liver*, with the exception of adenoma, are surgical rarities, at least as far as producing symptoms and operability are concerned. There have been observed fibroma, angioma, a fibromyoma lipomatodes sarcomatodes (Sklifosowski). The adenomata are of two kinds: nodular adenomatous hyperplasia of the liver not amenable to surgical treatment, and circumscribed tubular adenomata. As isolated tumors of the liver these have been successfully removed by a number of surgeons. They may undergo cancerous or cystic degeneration. Keen removed a supposed adenoma which proved to be due to infection of the liver with coccidia, a form of tumor rare in man, but common among certain herbivorous animals, notably rabbits (psorospermia).

Cancer of the Liver.—*Primary* cancer of the liver, the only type possessing any surgical interest, is much more rare than the secondary variety. The liver is, as has already been indicated in many places in this book, a very common position for the formation of metastatic tumors in cases of cancer, no matter what the situation of the primary growth. They are rather more apt to occur as complications of cancer of the stomach and intestine, uterus, biliary passages, than of cancers situated elsewhere, though very common after cancer of the breast. These secondary cancers of the liver occur as disseminated nodules and as massive infiltrations, and are, of course, in no case suitable for operative removal. One of their diagnostic features is that the nodules in the liver often are distinctly depressed or umbilicated in their centers, as discoverable by palpation. The *primary cancers* of the liver are usually of the type of adenocarcinoma. They may be single or multiple, and may originate as indicated from carcinomatous degeneration of an adenoma. They may occur anywhere in the liver, more often in the right lobe, sometimes as an isolated rounded nodule, sometimes as a diffuse carcinomatous infiltration. The former alone are capable of operative removal, and then only in the rare cases where the tumor is at or near the free border of the liver and happens to be discovered as a palpable nodule very early in the disease. When cancerous cachexia, ascites, emaciation, disturbances of digestion, obstruction of the portal circulation, dilated subcutaneous veins in the abdominal wall, anemia, jaundice, and the other symptoms of advanced cancer of the liver are present, the diagnosis is usually only too plain, notably in the presence of a massive tumor of the liver, and no operative treatment of a curative character is possible. The number of cancers of the liver operated upon successfully is very few. In 1901 Terrier and Auvray collected fifty-two operations for tumors of the liver. Of these, nine were primary cancer of the liver. One case, that of Schrader, was well at the end of seven years. A case of Terrier was well at the end of five months. In 1904 Leonard Freeman (*Transactions of the American Surgical Association*) reported a case of primary adenocarcinoma of the left lobe of the liver. The tumor was the size of a fist and was solitary. The patient was a vigorous man of twenty-seven who had suffered for a year or more from a feeling of heaviness and moderate pain in the region of the gall-

bladder, accompanied by slight jaundice and marked indigestion. Removal of the tumor was followed by good health and freedom from recurrence for at least sixteen months. In this case the tumor was palpable as a hard irregular mass, apparently no larger than a walnut, though really much larger, occupying the situation of the gall-bladder and moving with the liver. Keen removed successfully a primary cancer of the anterior border of the right lobe of the liver. The patient suffered a recurrence. McArthur in 1904 reported a successful case of adenoma or adenocarcinoma of the liver, probably the latter. The patient was alive and well three years and a half after the operation. When during the cancerous age we discover a single nodular firm tumor of the liver, with no special symptoms to suggest its character, it is very probably a cancer. If we wait until positive diagnostic signs and symptoms are present, we can no longer benefit the patient.

Sarcoma of the liver is common as a secondary tumor, notably in melanosarcoma. As a primary growth it is much less frequent than carcinoma, and has only very rarely been operated upon.

FLOATING LIVER, HEPATOPTOSIS. DISLOCATION OF THE LIVER. DEFORMITIES OF THE LIVER

As a part of a general enteroptosis, the free border of the liver may descend a variable distance below the free border of the ribs. The condition is usually observed in women, but is also seen in men. These patients have flabby and relaxed tissues, they have sometimes suddenly lost much flesh. Among women there will often be a history of several confinements; the abdominal wall will be found thinned out, often pendulous. The muscular and tendinous structures of the abdominal wall do not afford proper support for the viscera. The normal firm padding of fat within the abdomen is wanting, the visceral ligaments are feeble and stretched. Movable kidney, neurasthenia, and digestive disturbances are often present. The descent of the liver is variable; it may extend to the umbilicus or even to the right iliac fossa. Usually no difficulty exists in the diagnosis. The liver dullness commences at a lower point than normal above. The lower border of the right lobe is usually palpable, or can be mapped out by percussion. The tumor, if the abdominal walls are much relaxed, can be pushed upward into its normal position, or nearly so. When, as sometimes happens, there is a transverse furrow across the elongated right lobe, the lower portion may be mistaken for a movable kidney, a gall-bladder, or a movable tumor of the omentum, etc. Cases have been described in which the liver has entirely left its normal situation beneath the diaphragm and descended to the lower part of the abdomen, usually rotating at the same time, so that the free border looked to the left. In such cases the intestines would find their way between the liver and the diaphragm, producing a band of tympanitic resonance between lung and liver. When the liver is very movable under these conditions of displacement, it is spoken of as *floating liver*. If, as very rarely

happens, it becomes fixed by adhesions in an abnormal place, it is called a *dislocated liver*. A peculiar deformity of the right lobe of the liver is sometimes observed in women. The right lobe extends downward in a tongue-shaped prolongation a variable distance, a furrow may form across such a prolongation, and, becoming gradually deeper, the tip of the tongue of liver tissue may finally come to be united to the remainder of the right lobe by a constricted bridge. Absorption and atrophy of this bridge may occur, leaving a dependent lobule hanging as a freely movable mass connected merely by connective tissue with the remainder of the liver. The connection of such a tumor with the liver may not be easy to establish by physical examination. The intestine may, as stated, interpose itself between the elongated liver and the abdominal wall. This deformity of the liver is produced by the pressure of tight corsets; it is occasionally seen in much less marked degree in men who wear habitually a tight belt (corset liver). Two cases of congenital deformity of the left lobe of the liver are reported (Langenbuch, Hammond). In Hammond's case the left lobe of the liver was elongated in a tongue-shaped projection, which extended across the abdomen as far as the spleen. "A feeling of distention and pressure in the epigastrium, palpitation of the heart, and dyspnea, had been prominent symptoms from which she had suffered from her earliest recollection." When standing upright and hungry the symptoms disappeared. They were always present when lying on her back. The stomach was displaced downward. Resection of the elongated left lobe was followed by disappearance of the symptoms (Hammond, *Annals of Surgery*, January, 1905).

DISEASES OF THE BILIARY PASSAGES

General Remarks.—The size, shape, and position of the gall-bladder vary under normal as well as under pathological conditions. Most commonly the gall-bladder, or at least its fundus, lies beneath the ninth costal cartilage, and may be exposed readily through an incision passing downward from this point, through or along the outer border of the right rectus muscle. Under normal conditions the gall-bladder reaches to or projects a little below the free border of the right lobe of the liver. Under pathological conditions the size and situation of the gall-bladder with reference to the free border of the liver varies greatly. When dilated as the result of disease it may project as a sausage-shaped or pear-shaped tumor several inches below the border of the liver, or even as low as the iliac fossa. It may even become so large as to be mistaken for an ovarian cyst. On the other hand, as the result of inflammation, the gall-bladder may undergo an almost complete atrophy and exist as a small nubbin no larger than the last two joints of one's little finger, or as a mere cord, deeply hidden beneath the liver, and so buried in adhesions that it may be difficult to identify after the abdomen is opened. The gall-bladder may also be displaced out of its normal relations by adhesion; it may be drawn to the right or to the left, or posteriorly, so as to lie to one side of the kidney

in the lumbar region. The gall-bladder varies in thickness under pathological conditions as well as in the consistence of its walls. In conditions of acute distention and acute inflammation it may be thinned out, so that it is hardly possible to pass a suture without puncturing its lumen. Under such conditions the wall of the gall-bladder may be as friable as blotting paper. When the seat of chronic inflammatory thickening, the wall of the gall-bladder may be a quarter of an inch or more in thickness, and as dense and hard as cartilage. Considerable variations exist in relation to the under surface of the liver. The gall-bladder throughout the greater part of its length may have an almost complete peritoneal investment nearly to the beginning of the cystic duct. In other cases the gall-bladder will be closely adherent to liver substance, partly embedded, in fact, in the liver over its entire upper surface. In the first group of cases the gall-bladder will be very movable, and its extirpation, including its peritoneal covering, may be very simple. In the latter group the gall-bladder will be entirely fixed, and its extirpation, unless done by the subperitoneal method, may be difficult and attended by troublesome hemorrhage from the liver substance. It is better in any case when removing the gall-bladder to begin by placing a clamp on the cystic duct, beyond any stone which may be impacted in the duct; to place a second clamp distal to the first, divide the duct and make the dissection of the gall-bladder from the duct to the fundus. Much troublesome bleeding may thus be avoided. The cystic artery which supplies the gall-bladder with blood divides close to the beginning of the cystic duct into two branches, one of which supplies the peritoneal surface, the other the hepatic surface of the gall-bladder.

The *lymph channels* of the gall-bladder are few; one lymph gland is at the junction of the gall-bladder with the cystic duct; a second is at the point of union of the cystic and hepatic ducts, and there are several small glands which receive their lymph from the common duct itself. Murphy noticed and called attention to the influence which this arrangement has upon the absorption of septic products in inflammations of different portions of the biliary passages. The normal capacity of the gall-bladder in health is about an ounce and a half of bile. The outlet of the gall-bladder is the cystic duct, about an inch in length; it leaves the gall-bladder to the inner side of a small pouch formed by reduplication of the mucous membrane at the neck of the gall-bladder known as the pelvis. From the junction of the hepatic with the cystic duct to the papilla in the duodenum the canal is known as the common bile duct. It is about three inches in length. The first inch lies in the right border of the gastro-hepatic ligament in association with the hepatic artery and the portal vein. The remaining two inches lie behind the descending portion of the duodenum, the lower portion of this second division of the common duct lies partly in the head of the pancreas, and the last three quarters of an inch pass obliquely through the wall of the duodenum to empty through a very narrow orifice, the papilla of Vater in the posterior wall of the duodenum. Just above the papilla the duct is somewhat dilated, constituting the ampulla of Vater. The mucous

membrane of the cystic duct is thrown into folds, so that in conditions of health it is very difficult to enter the cystic duct with a probe. The point of the probe nearly always engages in the pouch at the neck of the gall-bladder, already spoken of as the pelvis; under conditions of disease the cystic duct may be dilated and the folds in its mucous membrane obliterated, so that it is easier to pass an instrument through the cystic and common ducts and so to the duodenum. When the common duct has been dilated by the accumulation of bile behind a stone situated usually in the ampulla of Vater, the caliber of the duct is often increased so much as to admit a medium-sized forefinger, and may thus permit the most accurate means of determining the presence or absence of a stone; this is especially true when a chronic pancreatitis is present—i.e., *the nodular pancreas simulates stone.* The neck of the gall-bladder and the common and cystic ducts are supplied by the lower dorsal and two upper lumbar nerves. This arrangement accounts for the deep-seated pain felt in the middle line in cases of biliary colic, and also for the accompanying spasm of the diaphragm (Jonas, Mayo). Kehr calls attention to the fact that the lymphatic gland which lies at the junction of the cystic with the hepatic duct may become enlarged and indurated as the result of inflammation, and may thus deceive the palpating fingers of the surgeon, giving the sensation of a stone. A similar condition may exist in the lymph nodes along the common duct. I have been momentarily deceived in this way a number of times. In examining the biliary passages the gall-bladder is the guide to the cystic duct and that to the common duct. The common duct is palpated by slipping one or more fingers through the foramen of Winslow, thus grasping the common duct. When no adhesions are present this manipulation is very simple; when the viscera in the vicinity are glued together, it may involve a troublesome dissection, sometimes accompanied by annoying bleeding. In such cases when operating for stone in the common duct a safer and more certain route is through the anterior wall of the duodenum, finding the papilla, dilating its orifice, and extracting the stone by this route (McBurney). Be the function of the gall-bladder what it may, its removal has no effect upon the health of the individual, and since it has come to be known that gall-stones originate nearly always in the gall-bladder, and that the gall-stones formed in the hepatic duct are very small, and may be generally disregarded in the treatment of gall-stone disease, it has come to be the general practice of surgeons at the present time when operating for gall-stones to remove the gall-bladder, unless certain special contraindications exist, as a matter of routine, thereby giving the patient the best guarantee of future immunity. This has been the author's practice for the past ten years in most of his cases. He is aware that many surgeons are not in accord with this view.

Disease of the biliary passages may lead to jaundice in a variety of ways: First, inflammatory swelling of the mucous membrane of the biliary ducts may produce jaundice by obstructing their lumena; the most simple example of this form of jaundice occurs in the cases of gastroduodenitis commonly seen in

young persons, and due to a swelling from catarrhal inflammation of the mucous membrane of the duodenum, extending probably slightly into the mucous membrane of the common duct with more or less complete closure of the papilla and the retention of bile. Second, gall-stones situated in the gall-bladder are not necessarily related in any way to jaundice; as long as they remain in the gall-bladder without a complicating infection and inflammation no jaundice will occur. But if they give rise to cholecystitis the inflammation travels to the common duct and gives rise to a cholangitis and to jaundice. Third, inflammation of the gall-bladder may be attended with localized peritonitis and adhesions; the common duct may thus be compressed with the production of jaundice. Fourth, a large stone impacted in the cystic duct may compress the common duct and produce jaundice. In my experience this is a very common occurrence. Fifth, the inflammation of the biliary passages may extend into the pancreas and cause a chronic pancreatitis with jaundice (Mayo). Sixth, a tumor, usually cancer, produces jaundice by mechanical closure of the common duct. Such a cancer may involve the papilla, the common duct, the head of the pancreas, or the gall-bladder itself, and the cystic duct, causing compression of the common duct with obstruction. A tumor may also cause obstruction by pressure from without, and thus jaundice. Seventh, a gall-stone situated in the common duct produces jaundice more or less marked, according to the degree of obstruction caused by the presence of the stone. The jaundice caused by simple inflammatory swelling of the mucous membrane of the papilla is usually not very marked, and its duration is relatively short. Jaundice caused by stone obstructing the common duct is much more intense, and usually lasts longer. It is apt, however, to vary in intensity from day to day, since the common duct is usually dilated above the stone, and from time to time the stone floats or is displaced a little, so that some bile escapes beyond it (the ball valve stone of Fenger). In many cases of common duct stone the jaundice is intermittent. There may, of course, be no jaundice. The jaundice produced by malignant disease, although commonly preceded by a history pointing to gall-stone, usually comes on slowly and gradually, but is steadily progressive, increasing in intensity without remission.

The *inflammations* of the biliary passages may be produced in a variety of ways; by far the most common accompaniment is gall-stone. The inflammation may be in the gall-bladder (cholecystitis), in the large bile ducts (cholangitis), or may involve the smaller branches of the hepatic duct in the liver (diffuse cholangitis). As in the vermiform appendix, the inflammation may be of different grades of severity; it may be a simple serous inflammation, fibrinous, purulent, putrid, phlegmonous, or diphtheritic, and the intensity of the local and general symptoms will vary with the character of the inflammation and with its situation, in more or less characteristic ways, as will be presently described. Inflammation of the biliary passages is always caused by bacterial infection, which may reach the biliary passages in the bile. The source of the bacteria is the intestine, whence they have passed through the

portal circulation into the liver. The blood of the portal vein constantly contains bacteria; under conditions of health they are partly or wholly destroyed in the liver, and the bile is sterile, or contains but few bacteria. In the conditions which lead to gall-stone disease the liver fails to remove all the bacteria, and infection of the biliary passages may take place. Infection may also take place through the papilla direct from the intestine, but the infection through the bile is believed to be more frequent. At present it is believed that gall-stones are always associated with bacterial infection and that the predisposing cause of their development in the gall-bladder is a cholecystitis. Musser showed that the majority of individuals who suffer from gall-stones have had previous mild attacks of cholecystitis. Bacterial infection of the biliary passages is favored by the presence or entrance of not only gall-stones, but other foreign bodies—intestinal parasites which enter the biliary passages, or actual foreign bodies swallowed, seeds, fish bones, etc.—trauma has already been spoken of as a cause under Injuries of the Biliary Passages and Liver. Further, the various essential fevers, notably typhoid, may be complicated by cholecystitis or a cholangitis caused by the typhoid bacillus itself, either during the existence of the fever or at a later period, even after years. It has also been observed after cholera and dysentery, and may occur as a complication of pyemia or septicemia and in the presence of cancer of the biliary passages, notably of an ulcerated cancer of the gall-bladder. Tuberculosis and actinomycosis have been observed as very rare affections of the biliary passages.

Gall-stone Disease.—The experience of surgeons throughout the world during the past ten years indicates that early diagnosis and early operation for gall-stone disease is of the greatest importance to the affected individual; thus William J. and Charles H. Mayo, in one of their most illuminating papers on this topic ("The Diagnosis of Gall-stone Disease," The *St. Paul Medical Journal*, February, 1905), write as follows:

> In reviewing the mortality of 1,000 operations for gall-stone disease we have been impressed with the very fortunate outcome where gall-stones were in the gall-bladder and therefore were complications. In the 1,000 cases there were 50 deaths, or an average mortality of 5 per cent. . . . The death-rate in 820 cases where the disease was confined to the gall-bladder and for benign conditions was 3 per cent. . . . In 416 cases of simple gall-stone disease the mortality was less than ½ of 1 per cent. The common duct operations amounted to 14.6 per cent of the whole. In 137 operations for common duct stones the mortality was 11 per cent. In 40 cases, or 4 per cent, malignant disease was discovered, and the operative mortality was 22 per cent. In practically all of these cases gall-stone irritation had been the cause of the development of cancer.

Owing to the careful observation and large experience of the Mayos, Kehr, Courvoisier, Riedel, Mayo Robson, Moynihan, Ochsner, to mention only a few of the distinguished surgeons who have labored in this field, the early and accurate diagnosis of gall-stone disease is possible in all but a small proportion

of cases, and yet, as Blake pointed out several years ago, in the hospitals of the city of New York, we receive our cases of gall-stone disease from the physicians who send them usually only after months or years of unavailing medical treatment; they are cases of deep and prolonged jaundice, of severe infection, of advanced lesions, of suppurative cholecystitis, etc. The mortality of these cases is necessarily much higher than it would be were physicians more ready to recognize that gall-stone disease is, where it gives serious symptoms at all, a purely surgical condition. Gall-stones occur but rarely in the young; they are common in middle life and exceedingly common in old age. They are five times as frequent among women as among men. It is estimated that gall-stones are found at autopsy in about one body in ten; in all but about five per cent of the cases no symptoms are produced, or symptoms so slight in character that the individual has never had his attention directed to his biliary apparatus.

Gall-stones consist of several ingredients; they consist of cholesterin, of cholesterin combined with bile pigments, of lime, or of combinations of these ingredients. They vary greatly in size and number. There may be but one or two stones, and these are usually quite large, as large as the last joint of one's finger, or, as in one case of my own, a single stone filled and was molded into the shape of a gall-bladder of about double the normal size, or, on the other hand, the stones may be numerous and small. I have frequently removed gall-bladders containing several hundreds of stones. The gall-bladder figured in the text contained a thousand. Or there may be a few large stones and very numerous small ones. When a number of stones are in the gall-bladder together they are usually faceted. Gall-stones may be dark greenish-black in color or brown, or yellow, or dirty white. Sometimes they occur in the gall-bladder as amorphous, soft granular masses. When one finds a solitary stone in the common duct it is frequently rounded or ovoid in shape with a rough mulberry-like surface, and a centimeter or a centimeter and a half in diameter. The size and number of the stones have but little bearing upon the symptoms; the accompanying inflammation and the position of the stone, such that it

FIG. 26.—GALL-BLADDER CONTAINING ONE THOUSAND CALCULI. (New York Hospital, service of Dr. Frank Hartley.)

causes obstructive symptoms, are important. Gall-stones can nearly always be demonstrated to contain bacteria. Apparently they only produce symptoms when associated with an inflammation of the gall-bladder.

When gall-stones in the gall-bladder are accompanied by cholecystitis, in the simple cases there occurs an attack of so-called *biliary colic*, the patient is seized with a severe pain, usually felt in the middle line of the abdomen beneath the ensiform cartilage; there is often an accompanying spasm of the diaphragm, producing a feeling of cramp; the pain is apt to radiate to the right, occasionally to the left; it is often felt in the back beneath the shoulder blade; it may radiate upward beneath the sternum. The attack of pain lasts for minutes or hours, and suddenly ceases; upon the cessation of pain the patient frequently vomits; the pulse remains normal, there is no rise of temperature. W. J. Mayo pointed out that *the absence of general symptoms of infection when the gall-bladder merely is involved* is due to the fact that the gall-bladder possesses but few lymphatics, and readily distends as its contents accumulate and are dammed back by the combined influence of the inflammatory swelling of the mucous membrane and the obturating effect of the stone, a point of great diagnostic importance in the opinion of the author.

The gall-bladder readily distends, its contents are under no great tension, and before absorption has taken place the patency of the cystic duct has been established and the attack is over. Following the attack the patient eats with a good appetite, feels quite himself again; there may remain a little tenderness and rigidity in the right rectus muscle near the free border of the ribs. It is usually possible to differentiate such an attack from appendicitis, because in appendicular colic the pain is referred to a lower point in the abdomen, to the umbilicus, or to the right iliac fossa, and there will usually be tenderness over the base of the appendix. Often there is a history of former characteristic attacks. In both diseases, as already noted, vomiting will be a regular symptom. As pointed out under the Diagnosis of Kidney Stone, there will be in this latter condition tenderness upon tapping the twelfth rib, or just below the twelfth rib on point pressure in the direction of the kidney. The radiation of pain in renal colic, also, is downward into the groin along the course of the ureter into the testes, the thigh, the perineum. There will usually be a history of urinary disturbance, and often changes in the urine. When a stone is impacted in the pelvis of the gall-bladder, not for a few minutes or hours but for a considerable length of time, the attack begins with pain such as described. But in these cases there will be marked tenderness in the region of the gall-bladder; the gall-bladder will become distended, and will often be palpable as a definite and characteristic tumor below the free border of the ribs, as already described. The constitutional disturbance, fever, and acceleration of pulse-rate will usually not be marked, and this may be true even when pus is present, on account of the deficient supply of lymphatics in the gall-bladder, and therefore the slow absorption. These cases must be differentiated from ulcer of the duodenum with periduodenitis by a history of gastric

disturbance more or less marked. Gastric disturbances are not necessarily present when a stone is impacted in the pelvis of the gall-bladder.

The following case history illustrates the fact that gall-stones situated in the gall-bladder may give rise to trifling constitutional disturbance, even though they may have caused pressure ulceration and a purulent inflammation of the gall-bladder, threatening immediate perforation with all its dire consequences. The case is one upon which the author operated in January, 1909. A woman, forty years of age, was admitted to the New York Hospital with the following history: During the past three years she had suffered from time to time with attacks of epigastric pain, which had been diagnosticated by her physician as acute gastric dyspepsia. Twenty-four hours before her admission to the hospital she was suddenly seized with severe pain, referred to the right upper quadrant of the abdomen, and came to the hospital. Upon admission she complained of very intense pain in this region. She had not vomited. There were no notable constitutional symptoms. Her temperature was normal, her pulse was only slight accelerated; her blood count showed no notable increase of leucocytes, nor were the polynuclear cells relatively increased in number. She was not jaundiced. Palpation of the abdomen showed nothing abnormal except moderate tenderness over the region of the gall-bladder. The patient was kept under observation for twenty-four hours. No new symptoms developed, but the pain in the region of the gall-bladder continued severe. At the end of thirty-six hours the gall-bladder was removed. It contained two large stones, one of them impacted in the neck of the gall-bladder, where it had produced pressure ulceration of the mucosa and muscular coat. The necrosis had extended almost to the peritoneal coat, and perforation would probably have occurred within a day or two. The gall-bladder contained muco-pus. Normal convalescence.

Within a week of the time when the author operated upon this case he saw and operated upon another, in whom the symptoms were almost identical with the first, but where the distended gall-bladder was distinctly palpable below the free border of the ribs. Although the gall-bladder of this patient was filled with stones, the patient stated that she had never had a severe attack of pain in the abdomen, nor had she ever been jaundiced. In this case there was purulent cholecystitis. The cystic duct at its junction with the gall-bladder was the seat of a narrow stricture. A small stone was impacted just distal to this point of narrowing. The gall-bladder was removed. Normal convalescence.

A stone once impacted in the neck of the gall-bladder, the subsequent history of the case may vary in a number of ways; quite commonly, as the result of chronic inflammation, the fluid contents of the gall-bladder, if reasonably free from virulent bacteria, undergoes a slow absorption, the gall-bladder shrinks and finally grasps the stones firmly; its contents consist simply of the stones and a little mucus or muco-pus. Peritonitis, with adhesions, is very commonly present around the shrunken gall-bladder. Such adhesions may compress the common duct with the production of jaundice. In these cases

the attacks of colic cease and the patient goes on to suffer with symptoms of gastric dyspepsia. If the adhesions are extensive they may cause constriction of the pylorus, a dilated stomach, and the signs and symptoms of pyloric stenosis, as already described. In some cases the stones may cause pressure ulceration of the neck of the gall-bladder and a gangrenous cholecystitis. The following case history illustrates the possibilities of this condition:

A middle-aged man, who had previously enjoyed good health but who had suffered from occasional attacks of discomfort in the epigastrium, but with nothing resembling a biliary colic, was brought to the hospital with the history that he had had a sharp attack of pain in the upper part of the abdomen coming on two days before; since then the pain had continued to grow worse. He had vomited once. Upon admission to the hospital his temperature was 100° F., his pulse 110; his leucocyte count was 15,000, with ninety per cent of polynuclear cells. He looked severely ill. The entire right side of the abdomen was tender and rigid, but the tenderness was most marked in the upper right quadrant. The diagnosis of acute cholecystitis was made. Owing to the extreme tenderness and the thickness of the abdominal wall, the gall-bladder could not be palpated until after the patient was under the anesthetic. The gall-bladder was then felt as a tumor projecting downward some five inches below the free border of the ribs. The liver was not enlarged. The gall-bladder was sausage-shaped, and felt about two inches or more in diameter. It was movable from side to side. Upon opening the abdomen the gall-bladder was found to be greatly distended and very tense. It was almost black in color, and toward the cystic duct it was evidently gangrenous and about to perforate. There was a little thin, serous fluid in the peritoneal cavity, and some recent fibrinous exudate on the surface of the gall-bladder and the neighboring viscera. A pint of dark bile mixed with pus was aspirated from the gall-bladder. Cultures from the contents of the gall-bladder showed the presence of the Bacillus coli communis. After aspiration numerous large calculi could be felt in the gall-bladder, and one, about the size of the last joint of a man's thumb, was impacted at the gall-bladder's neck. This was the stone which had produced the pressure necrosis, and finally gangrene. The gall-bladder was removed, and the cystic duct, being patent, was left open and a rubber tube, stitched in position in connection with the duct, was brought out of the abdominal wound. The constitutional infection in this case had been severe, and convalescence was delayed by the development of an empyema of the thorax on the right side, which necessitated the resection of a rib. At no time had this patient exhibited the symptom of jaundice. He finally made a perfect recovery, and is now in good health.

In other cases adhesions will take place between the gall-bladder and the colon. In these cases perforation may take place so slowly that no definite symptoms at all are produced. The patient may suffer as the result of the

perforation from a moderate catarrhal colitis, and stones may be passed *per rectum*. In regard to the passage of gall-stones *per rectum*, it may be said that the appearance of stones in the feces, if they be as large or larger than a cherry pit, indicates that they have passed through the ulcerated gall-bladder into the intestine rather than through the common duct (Kehr). It is also to be borne in mind that subsidence of acute symptoms of biliary colic, followed by the passage of gall-stones *per rectum*, scarcely ever indicates a cure of the disease. There are nearly always other stones left behind which do not pass. Gall-stones may be entirely disintegrated in the bowel, and their passage in many cases after they have reached the intestine is long delayed, so that they may not appear for days or weeks. Ulceration may also occur into the duodenum or into the stomach, and in these cases, as has already been pointed out, if the stone be large it may produce intestinal obstruction by obturation anywhere from the pylorus to the ileo-cecal valve; ulceration into the liver substance will produce an abscess of the liver, with general septic symptoms and the local signs of abscess of the liver, as already described. Occasionally the gall-bladder is suddenly perforated into the general peritoneal cavity. This result would undoubtedly have taken place in a few hours or a day in the last case mentioned. The signs and symptoms will be those of peritoneal sepsis, diffuse purulent peritonitis, or localized peritonitis with the formation of an abscess, according to the severity of the infection.

It is further to be borne in mind that an attack of biliary colic and its subsidence rarely means that a gall-stone has made a successful passage from the gall-bladder to the intestine, or even that it has passed out of the gall-bladder at all; the attack indicates cholecystitis with its associated inflammatory obstruction of the cystic duct, sometimes aided by the presence of stone, but not always. The following case history illustrates cholecystitis, peritonitis with adhesions, obstruction of the cystic duct by a sharp kink, not associated at the time of operation with calculi:

Richard D., aged fifty-six, a temperate man, had suffered from pretty sharp attacks of gastric dyspepsia in the past. Three months ago a typical attack of biliary colic. Since then he had frequent attacks of pain, referred to the umbilicus. No jaundice. On the day after admission the pain became decidedly worse. He vomited. On admission to the hospital: temperature, 101° F.; pulse, 90; slight leucocytosis; polynuclears not markedly increased. There was tenderness and rigidity in the right upper quadrant of the belly. Abdominal wall rather thick. Liver of normal size. Gall-bladder not felt. Upon opening the abdomen the gall-bladder was found buried in adhesions gluing it to the colon, liver, and duodenum. The gall-bladder was distended and tense. A sharp kink existed in the cystic duct, as the result of the adhesive peritonitis. Upon separating these no evidence of a former perforation into the intestine could be seen. After the adhesions about the neck of the gall-bladder had been separated, the viscus emptied itself spontaneously and almost

completely into the intestine. No stone could be felt. There were several enlarged lymph nodes along the course of the common duct. Cholecystectomy, ligature of cystic duct. Normal convalescence and subsequent freedom from symptoms. The gall-bladder was thickened in all its coats, and showed the lesions of chronic inflammation. The mucous membrane was markedly thickened, and showed spots of superficial erosion here and there.

If, as sometimes happens, the cystic duct is obliterated by inflammation or is entirely closed by an impacted stone after one or more acute attacks, the condition may become quiescent, the contents of the gall-bladder sterile. The gall-bladder then remains as a cystic tumor, giving no symptoms, or indefinite symptoms merely, pain in the epigastrium, or a sense of discomfort. Its contents will consist of nearly clear mucus, the bile pigments having been absorbed. Such a gall-bladder may be discovered as a painless, movable tumor by accident by the patient or physician. It may be differentiated from movable kidney by the fact that though it can be pushed away from the abdominal wall, it returns to its place. A movable kidney, palpated with both hands with the patient on her back, slips away from between the fingers and returns to the loin in a very characteristic and unmistakable manner, and descends again only on deep inspiration or upon rising to the erect posture. It is always to be borne in mind that infection may be lighted up again in such a gall-bladder at any time. If such a gall-bladder is small and contracted, no tumor can be felt. If it becomes reinfected, acute symptoms will appear.

Hitherto we have described cases without jaundice. Whenever cholecystitis infects the deeper bile passages, jaundice may occur as the result of cholangitis, and that though no stone has left the gall-bladder. As already stated, if the inflammation extends from the common duct into the pancreatic ducts the swelling of the head of the pancreas, due to chronic inflammation, may compress the common duct and cause jaundice. The following case, operated upon in 1906, illustrates the condition:

C. D., a temperate man, a physician, aged forty-six, came under my care with the following history: Two years ago a typical attack of biliary colic, repeated at intervals of a few months. Six months ago he first became jaundiced; the jaundice was accompanied by pain and tenderness in the region of the gall-bladder, by digestive disturbances, and occasional attacks of vomiting, but the sharp attacks of colic did not recur. The jaundice lasted three weeks. Transient jaundice has occurred twice since then. During the past six months he has lost much flesh and strength and has become anemic. At present he has been jaundiced for a fortnight. Abdomen flat. Liver extends one inch below costal border. Temperature, 99° F. Pulse, 70. Gall-bladder not felt; slight tenderness on deep pressure beneath the right lobe of the liver. Operation. Numerous adhesions between gall-bladder and surrounding structures. Gall-bladder contracted; two inches and a half in length and three fourths of an inch thick at fundus. It was tightly packed with calculi, and contained a few drops of thick mucopurulent fluid. Lumen

obliterated at junction with cystic duct. Gall-bladder removed. Free flow of bile from cystic duct. Probe passed down common duct into duodenum. Head of pancreas enlarged and firm; evidently the seat of chronic inflammation. No stone felt in either common or hepatic ducts. Cystic duct left open for drainage, a rubber tube sutured to its stump. Gauze packing. Partial suture of abdominal wound. Normal convalescence. Jaundice gradually passed away during following month. Since then he has returned to normal health.

When a stone leaves the gall-bladder and enters the cystic duct the constitutional symptoms of septic absorption are usually much more marked than when cholecystitis exists alone. The duct distends much less readily than the gall-bladder, and its lymphatic channels are more abundant. The patient will suffer from sharp attacks of fever from time to time, sometimes accompanied by chills. The fever will be accompanied by deep-seated pain, lasting for hours or days. There may be jaundice. Such jaundice is usually of a moderate grade only, and is temporary. In all cases where jaundice is present the urine is more or less stained by bile. The color of the urine will vary from dark amber to dark beer color. A chemical examination readily detects the presence of bile pigments. As already noted, when jaundice is intense the stools are gray or clay colored, and their color will vary from that to a normal brown, according to the degree of obstruction. When stone is impacted in the cystic duct the jaundice will usually be caused by the pressure of the stone upon the common duct, and this obstruction is rarely complete. The intensity of the symptoms, the continuance and the height of the fever, varies a good deal in these cases, according to the degree of obstruction of the cystic duct, the distensibility of the gall-bladder, and the severity of the accompanying cholecystitis. The process may in some cases end in a latent stage. For the varieties in the symptoms, see Kehr's diagnostic chart. The Mayos consider this the least characteristic stage of the disease.

Stone in the Common Duct.—When the stone leaves the cystic duct and enters the common duct the symptoms depend partly on the biliary obstruction causing jaundice and partly upon septic absorption and localized infection. When the obstruction is absolute the symptoms are usually very characteristic indeed. Jaundice is rapidly produced, of an intense degree. The patient is seized with severe pain, often with a chill and a sudden rise of temperature. The fever is marked. In these cases the fever is often of a distinctly malarial type. Following the chill the temperature may rise to 104° to 105° F. or more, with a sudden drop, sometimes followed by profuse sweating. The fever is distinctly intermittent. Pain is present in a large proportion of cases, and is usually severe and paroxysmal in character if the obstruction is complete. The fever and the jaundice appear to vary according to the degree of septic absorption and of cholangitis. If the stone passes into the duodenum the symptoms will subside, but it is to be borne in mind that subsidence of the symptoms does not indicate that the stone has passed through the papilla except in a small

proportion of cases. If the duct dilates behind the stone the stone may, as already stated, float back in the bile, acting like a ball valve, as described by the late Christian Fenger, permitting the escape of a certain quantity of bile and a remission of the symptoms. The intensity of the jaundice may thus vary from day to day.

After a variable period in about one quarter of the cases, according to the experience of the Mayos, the disease may become quiescent, the symptoms abate or even disappear. Such a period may last for weeks or months. It is the common experience of all surgeons that operations done for common duct stone during the period of quiescence, if such occur, is far less dangerous than when done during the stage of acute obstruction. Thus the Mayos found that their mortality in operations for common duct stone during the period of quiescence amounted to only two per cent, whereas those done when marked cholangitis was present, when jaundice was deep and prolonged, had a mortality of from ten to thirty per cent. In the cases where the obstruction continues absolute, or where there is but a slight flow of bile around the stone, these patients become intensely jaundiced. They become anemic and emaciated, the power of coagulability of the blood is diminished or lost, subcutaneous hemorrhages may occur. If patients are operated upon in this stage they usually die; some of them bleed to death; in some of them, upon opening the common bile duct no bile escapes; the liver has ceased to functionate, and after the operation the liver does not resume its function. If operated upon at a somewhat earlier date the bile passages may be found filled with dark-green, flocculent bile. Some of these—about half, according to the Mayos—recover.

In the presence of obstructive jaundice Courvoisier's law should always be borne in mind—namely, that in the majority of instances obstructive jaundice with a palpable gall-bladder tumor indicates a *tumor* obstructing the common duct rather than a stone, whereas deep jaundice without a gall-bladder tumor indicates obstruction of the common duct by a stone, in the majority of cases. There are, of course, exceptions to this law. A secondary stone may form within the cystic duct, and thus produce distention of the gall-bladder if, as sometimes happens, this organ is not already contracted by previous attacks of inflammation. The pain of common duct obstruction is more apt to radiate toward the back and beneath the sternum than is the case when the gall-bladder alone is the seat of disease, when it is usually referred to the gall-bladder region itself or to the stomach.

In an article written some years ago, Kehr of Halberstadt published a very carefully prepared and complete diagnostic chart of the diseases of the biliary passages based upon his own long and extensive study of these cases. In this chart the salient diagnostic features of the various types of disease of the biliary passages are so accurately portrayed and Professor Kehr's opinions are entitled to so much weight that I feel obliged to reproduce the chart in this book, believing that it is worthy of the most careful study.

Type of Disease	*Symptoms*	*Diagnosis*	*Treatment*
(1) Stones in the gall-bladder, whose walls are but little or not at all changed. The cystic duct is patent. Contents of gall-bladder clear; bile free from virulent bacteria. No adhesions.	Symptoms are nearly always absent (latent period). Only now and then stomach pain (due to temporary closure of the cystic duct). No jaundice. No stones passed. No enlargement of the liver.	Palpation negative, or at most slight tenderness in the region of the gall-bladder on bimanual palpation. Often confounded with peptic ulcer, colic, movable kidney, hernia in the linea alba.	Medical, in the first place. At Carlsbad or Neuenahr, in order to establish, when possible, the continued latency of the cholelithiasis.
(2) Acute cholecystitis in a relatively healthy gall-bladder. Ordinarily a large stone is present in the neck of the gall-bladder. The exudate cloudy to purulent. Gall-bladder thickened.	Tumor of the gall-bladder. Riedel's lobe. Jaundice rare. Severe pain (stomach). Enlargement of the upper part of the abdomen. Marked tenderness on pressure. General condition, if the infection is slight, but little altered. If the infection is severe, much altered. (Cholecystitis acutissima complicated by cholangitis.) Circumscribed peritonitis (pericholecystitis). Fever present or absent. Liver enlarged only when cholangitis coexists. Passage of stones rare. If the cholecystitis ends in the passage of a stone, acute closure of the common duct may occur (9).	Diagnosis easy. Confusion with appendicitis is possible, notably if the appendix lies high up in the vicinity of the liver. The diagnosis must determine that the tumor is really the gall-bladder (form, mobility, tension, etc.).	Operative treatment best. Under medical treatment (purgatives) the acute inflammation often subsides; the stone remains. In cases of cholecystitis, cystostomy is the normal procedure.
(3) Stones in a gall-bladder already the seat of an in-	Similar to No. 1. Frequently severe colics, due to angu-	Diagnosis similar to No. 1. During the colics a tumor	When the symptoms recur frequently the opera-

Type of Disease	*Symptoms*	*Diagnosis*	*Treatment*
flammatory process. Cystic duct patent at the moment. Adhesions between the gall-bladder and neighboring viscera (intestine, omentum).	lation of the cystic duct, the gall-bladder being distended. Often accompanied by vomiting and pain on pressure. In the intervals between attacks there may be no symptoms (latent period).	of the gall-bladder may be present when the viscus is still capable of inflammatory dilatation. In the intervals palpation is often quite negative.	tion of cystectomy is urgently indicated, with drainage of the hepatic duct. Carlsbad cures in these cases rarely permanent.
(4) Acute cholecystitis in a gall-bladder already contracted from numerous attacks of previous inflammation. Cystic duct obliterated or closed by a stone. Many adhesions. Small amount of exudate, mucoid or purulent. Fistulæ may exist between the gall-bladder and intestine.	No palpable tumor, because it lies high up underneath the liver. Pain as in No. 2. More frequent changes in the symptoms. Jaundice rare. When present, a stone has usually passed from the cyst into the common duct.	The diagnosis, on account of the negative results of palpation, is difficult. A careful study of the history is the best aid to a diagnosis. When the general infection is severe purulent cholecystitis without a recognizable tumor, and in the absence of typical colic has often been mistaken for typhoid fever, malaria, and sepsis. These forms of gall-stone disease — 3 and 4 — belong to the chronic relapsing form of cholecystitis.	Cystectomy. Fifty per cent of these cases are not benefited by a Carlsbad cure.
(5) The same as No. 3. No stones, however, are present; merely adhesions.	Pain upon change of posture, as by standing up; otherwise the same as No. 3. The adhesions may produce pyloric stenosis, dilatation of the stomach, intestinal obstruction.	The same as No. 3. After the disease has lasted for some time the general health suffers severely. Physical signs of a dilated stomach.	Cystectomy. Gastroenterostomy.

Type of Disease	*Symptoms*	*Diagnosis*	*Trea*
(6) Hydrops of the gall-bladder. Cystic duct obliterated or closed by a stone. Contents of the gall-bladder clear, for the most part sterile. Gall-bladder wall as thin as paper.	There may be no symptoms. The presence of the tumor alone calls the attention of the patient to the fact that something is wrong. In other cases, pain in the stomach. No gall-stones are passed; no jaundice; no enlargement of the liver. Sometimes Riedel's tongue-shaped lobe is discoverable. The sterile contents of the gall-bladder may become infected at any time. (Hematogenous infection is also possible?)	Diagnosis is simple. Care must be taken not to confuse the condition with movable kidney. If there are no adhesions the tumor is movable laterally, may be pressed down into the depths of the abdomen, but at once resumes its former position. Tenderness on pressure slight. Hydrops in a contracted bladder forms no palpable tumor. Diagnosis as in No. 4—not easy.	Cystec
(7) Empyema of the gall-bladder. Pus in the gall-bladder. Stone in the cystic duct. Adhesions.	In the beginning as in No. 2. Later there may be no fever. Symptoms as in No. 6. The tumor is usually smaller than in No. 6. No stones are passed. The pains are more confined to the region of the gall-bladder and to the epigastrium. They are less apt to radiate toward the back, the breast, etc.	Aspiration of the gall-bladder not permissible. Otherwise as No. 4. Perforation causes the signs of diffuse peritonitis. In the beginning a gall-bladder which contains pus is very painful. Later the pain may diminish or disappear. Localized purulent exudates in the belly are not infrequent.	Cystec
(8) Cancer of the gall-bladder containing stones.	In the beginning, disturbances of digestion. No jaundice. If the common duct and the portal plexus of	Painfulness slight. Early diagnosis difficult, usually only upon the occurrence of jaundice. The develop-	Only operati successfu tomy, wi erable re liver sub

ype of Disease	Symptoms	Diagnosis	Treatment
	lymphatics are affected, jaundice and ascites will occur. Tumor hard and uneven. Later, cachexia. Colics are frequently absent.	ment of ascites, due to the pressure of glands upon the portal vein, renders the diagnosis easy. A cancerous gall-bladder with stone frequently becomes infected (empyema).	empyema coexists, cystostomy is of little use.
9) Sudden closof the common t by a stone.	Intense jaundice, colic, vomiting, chills, fever. The symptoms diminish or disappear if the stone passes into the duodenum, or falls back. In the first case the passage of the stone, yet the stone may not appear in the feces for weeks, or not at all.	Diagnosis simple. Typical history of former attacks of colic. The pains radiate more to the breast and back. In cholecystitis they are more confined to the region of the gall-bladder and stomach.	Morphin, hot applications. Operation only exceptionally necessary (drainage of the hepatic duct).
)) Chronic re of the comduct by a . The stone in supraduodenal on.	Moderate jaundice, which may be absent. Is apt to vary in intensity from day to day. Stools sometimes brown. Frequently intermittent fever of a malarial type. Pain is commonly present, but may be absent. The patients finally become cachectic in appearance and develop the hemorrhagic diathesis.	The gall-bladder is ordinarily contracted and not palpable. Liver more or less enlarged. Pain on pressure nearer the middle line. The spleen is often enlarged.	Incision of the common duct. Cystectomy and drainage of the hepatic duct.
:) Chronic e of the comluct by a stone ed in the pa-	Symptoms the same as in No. 10. Jaundice commonly intense; less often	As in group 10, the gall-bladder is small and contracted, if former at-	There is the possibility of a fistulous opening between the common

Type of Disease	*Symptoms*	*Diagnosis*	*Treatment*
pilla of the duodenum.	of varying intensity. If the inflammation subsides the jaundice may disappear.	tacks of inflammation have occurred which diminish its distensibility. Under other conditions it may become dilated into a palpable tumor. The contents of the gall-bladder consist often of pus.	duct and the du denum. If, aft three months, i improvement occu as the result medical treatme (Carlsbad), incisi of the duodenu dilatation of t papilla, and remo al of the stone.
(12) Chronic closure of the common duct by a tumor in the pancreas (carcinoma, interstitial pancreatitis), a tumor of the duodenum (papilla), or closure by obliteration of the common duct.	Intense jaundice, which is rarely variable in intensity, but continues to increase. Stools continuously clay-colored. There is usually no fever. Pain is slight or wanting, and, if present, is dull and rarely colicky.	The gall-bladder is commonly enlarged. The liver is enlarged. Tenderness on pressure is wanting or slight. The spleen is frequently enlarged.	Expectant trea ment, cholecyste terostomy (with t danger of a chola gitis). Operation cases of carcinon of little use. cases of chron pancreatitis, great value.

Operative Indications.—While not a part of surgical diagnosis, I a impelled to write a few words in regard to the operative indications of ga stone disease. During the past few years a good many American surgeo have come to regard cholecystectomy as the operation of choice in gall-sto disease. Personally, during the past ten years I have removed the gall-bladd in most of my cases, except where the condition of the patient permitted on a very short operation, or where an inoperable malignant growth existed, where the patient was so profoundly cholemic that death from hemorrhage w feared, or where the mechanical conditions such as perforation of the ga bladder with abscesses in the vicinity rendered the operation impracticab Nor do I believe that the mortality of my operations has been increased, a I am under the impression that the popularity of cholecystectomy, as opposed cholecystostomy, is steadily gaining ground as giving the patient the best gu antee against future trouble, not only in conditions affecting the gall-bladd merely, but also in conjunction with the removal of stones from the comm duct. That this opinion is not entertained by surgeons of far greater expe ence than mine in gall-stone surgery, I am well aware. Thus, Mayo Robs (*British Medical Journal*, February 24, 1906) states, in substance, as follow

In ordinary cases of cholelithiases, cholecystotomy with drainage of the ga bladder is a very safe and efficient operation, and if the ducts are cleared there ne

be no fear of fistula or of recurrence of gall-stones. Cholecystectomy is indicated in the following conditions: 1. In cancer or other new growth where the disease is local and limited. 2. In contracted and useless gall-bladder, the result of repeated attacks of cholecystitis. 3. In dilated or hypertrophied gall-bladder resulting from obstruction in the cystic duct. 4. In phlegmonous or gangrenous cholecystitis. 5. In empyema, calcareous degeneration, or mucous fistula of the gall-bladder. 6. In gunshot or other serious injuries of the gall-bladder or cystic duct. It is unnecessary in ordinary cholelithiasis.

At the present time—March, 1909—the pendulum has swung apparently in the opposite direction. That is to say, many surgeons believe that when the pancreas is swollen—i. e., when chronic pancreatitis is present as a complication of gall-stones—the indication for drainage of the biliary passages into the intestine is better fulfilled by making an anastomosis between the gall-bladder and the intestine, preferably the duodenum when practicable. Thus, W. J. Mayo says (*Surgery, Gynecology, and Obstetrics*, December, 1908, pages 607–613):

It can readily be seen that when the pancreas, as the result of infection, becomes swollen and causes pressure upon the common duct, that it seriously interferes with biliary drainage, and, though the pancreas may have become involved secondarily, it prevents that free drainage of the liver secretions which is so essential to the relief of the infection upon which the pancreatitis depends. The surgical treatment of chronic pancreatitis is not usually directed to the pancreas itself unless pancreatic calculi or other foreign bodies be present, but rather to the biliary tract, and is best accomplished by diverting the bile to the surface by means of a cholecystostomy, or to a new point in the gastro-intestinal canal by cholecystenterostomy.

In the large majority of cases, gall-stones in the gall-bladder or biliary tract are the direct cause of the chronic pancreatitis. Up to September, 1908, in 2,611 operations upon the gall-bladder and bile tract (C. H. and W. J. Mayo), the pancreas was coincidentally involved 200 times, or 7.6 per cent. In 325 operations on the common and hepatic ducts, the pancreas was involved in 22 per cent.

When gall-stones are present the removal of these stones with temporary free drainage by means of a cholecystostomy can usually be depended upon to cure chronic pancreatitis. The infection caused by the stones is readily relieved by this drainage, and in a comparatively short time the pancreatic pressure upon the common duct disappears and a permanent cure ensues.

In those cases of chronic pancreatitis in which no stones are present, cholecystostomy cannot be relied upon, because the continuation of the pancreatic disease lies outside of and beyond the biliary tract, and in these cases more prolonged, if not permanent, diversion of the bile from its pancreatic association is necessary, and cholecystenterostomy is indicated.

In regard to the necessity in certain cases of the direct drainage of the hepatic duct, this depends upon the presence and intensity of an existent cholangitis. When septic symptoms are slight or absent, experience shows

that after the removal of the gall-bladder, or incision of the common duct for the purpose of removing a stone, such drainage as is furnished by the cystic duct, on the one hand, or from the partly sutured common duct, on the other, properly supplemented by a rubber drainage-tube, furnishes all the drainage necessary. In septic cases it may be wise to introduce a small rubber tube into the hepatic duct and hold it by fine sutures. The suggestion of Mayo is a valuable one—namely, a notch cut in each side of the deep end of the tube permits bile to pass on and out through the papilla at any time, and yet furnishes just as complete drainage. I append the histories of two cases of common duct stone illustrating the fact that in aseptic cases no special drainage is necessary.

Case I.—E. M., female, aged twenty-two years, was admitted to the New York Hospital. Two months ago this patient began to have attacks of cramplike pain in the right hypochondrium, radiating to the shoulder and back, accompanied by chilly sensations, fever, and vomiting, but no jaundice. These attacks have been repeated every few days since. They have lasted from twenty-four to forty-eight hours and have confined the patient to bed. Four days before admission to the hospital an attack set in, and the patient noticed, twenty-four hours later, that she was jaundiced and that her urine was very high-colored. Stools not noted. Bowels regular. The pain had shifted to the epigastrium in the median line. On admission, the patient was well nourished and in good general condition. She was markedly jaundiced. The abdomen was flat. There was tenderness on deep pressure in the right hypochondrium and in the epigastrium. The liver did not appear to be enlarged. The gall-bladder could not be distinctly felt. The urine contained much bile. The stools were clay-colored. Temperature, 100° F.; pulse, 106; leucocytes, 10,000.

The following morning the patient was put under gas and ether. A vertical incision was made along the outer border of the right rectus muscle three and a half inches long, beginning above at the free border of the ribs. The gall-bladder was found distended. Palpation of the common duct between a finger introduced into the foramen of Winslow and the thumb detected a small hard mass low down in the common duct.

With some difficulty this portion of the duct was brought into view, and a small incision over the hard body permitted the extraction of a spherical calculus about the size of a pea. The removal of the calculus permitted the escape of a considerable quantity of bile-stained mucus. The gall-bladder then collapsed.

The cut in the common duct was sutured imperfectly with fine catgut. The exposed viscera was cleansed with salt solution and dried. Closure of the wound in the abdominal wall. Drainage with a rubber tube and a strand of gauze down to the hole in the common duct.

There was no rise of temperature following the operation, nor any disturbance of wound healing. A large movement of the bowels, containing abundant bile, on the second day. Drainage removed on the third day. Stitches removed on the eighth day. The jaundice had notably diminished after three days, and had entirely disappeared after ten days. The patient was allowed to sit up on the twentieth day. Urine and stools normal.

CASE II.—H. H., forty-six years of age, was admitted to the New York Hospital. During the past eight years she had suffered from numerous severe attacks of pain in the region of the gall-bladder. The attacks lasted for several days and were often followed by jaundice. During the past four years the attacks have recurred every two months or so. During the past three months the patient has had severe attacks of biliary colic, and the jaundice has been constant, with remissions. The last attack began four days before admission to the hospital. The pain lasted two days and a half, accompanied by a chill, followed by fever and sweating.

At the present time the patient is well nourished; she is deeply jaundiced. The abdomen is soft. The liver extends an inch below the free border of the ribs in the nipple line. There is tenderness in the region of the gall-bladder upon deep pressure. The urine and the stools are characteristic of biliary obstruction. The coagulation of the blood is notably delayed.

Under gas and ether anesthesia, a three-inch vertical cut was made at the outer border of the right rectus, beginning above, an inch below the free border of the ribs. The gall-bladder was found rather deeply placed beneath the liver. Moderately distended. Palpation detected a stone of considerable size in the gall-bladder. Palpation with the finger introduced into the foramen of Winslow detected two large stones in the common duct. Gall-bladder opened, permitting the escape of bile-stained mucus. A single stone, measuring three quarters of an inch in its greatest diameter, was extracted by means of a scoop. Efforts to move the stones in the common duct upward into the gall-bladder were not successful. An incision of the common duct behind the duodenum, permitting extraction of two stones of about the same size as the first. Suture of the common duct and the gall-bladder with fine silk. Cavity cleansed with salt solution. Closure of the wound, except for a small rubber drainage-tube and a strand of gauze which were introduced down to the wound of the common duct. Sterile dressing.

There was a slight escape of bile into the dressing for about forty-eight hours; after that time, none. The tube was removed on the third day, after which a small gauze wick was inserted a short distance for several days longer.

The movements from the bowels contained bile on the third day. The wound-healing was aseptic, producing a linear scar. The disturbance of pulse and temperature during convalescence were unimportant. The patient left the hospital on the twenty-fifth day, well.

TUMORS OF THE GALL-BLADDER AND OF THE BILIARY PASSAGES

A variety of benign tumors of the gall-bladder have been observed. They are scarcely likely to admit of an accurate diagnosis before operation. If they cause obstruction of the biliary passages they will produce symptoms more or less resembling those due to gall-stones.

Cancer of the Gall-bladder.—Cancer of the gall-bladder is relatively a frequent disease. By far the commonest cause is chronic irritation produced by gall-stones. Thus, Musser collected one hundred cases of cancer of the gall-bladder. In sixty-nine of these gall-stones were also found, and in many of the remaining cases there was a history pointing to gall-stones.

The *secondary cancers* of the gall-bladder, due to extension from cancer of the liver, etc., are without surgical interest. *Primary cancers* of the gall-bladder, on the other hand, are interesting for two reasons: First, if operated upon very early they are curable in a very small percentage of cases. Second, if already involving surrounding structures, the diagnosis of cancer is a positive contraindication to operative interference.

Two principal forms of cancer of the gall-bladder are distinguished by Morin: cancer arising from the epithelium of the gall-bladder; cancer arising from the glandular cells of the mucous membrane of the gall-bladder. The first form rapidly infiltrates the liver substance and clinically cannot be distinguished from cancer of the liver. The second form remains for a longer time confined to the wall of the gall-bladder, and may grow to a considerable size before the liver itself is invaded. In the larger number of cases the disease begins near the fundus; in other cases the vicinity of the neck is the starting point. Pressure upon the common and hepatic duct in these cases is accompanied by jaundice in the later stages of the disease.

Cancer of the gall-bladder rarely occurs before the fortieth year of life, and becomes more frequent with advancing age. As is the case with gall-stones, it is several times as frequent in women as in men, whereas malignant disease developing primarily in the common duct occurs with equal frequency in men and women.

One of the difficulties in the early diagnosis of cancer of the gall-bladder is that it is so frequently accompanied by the presence of gall-stones, and hence, that the symptoms during the early stage of the disease are mistaken for those of cholelithiasis; nor are there any definite symptoms pointing to a new growth until a palpable tumor is formed. Mayo points out, however, that while there will usually have been a distinct history of gall-stones in these cases, there will often be a distinct period of remission before the symptoms due to the cancer develop. The only cases in which operation is likely to be successful will be those, with few exceptions, in which the operation is done for supposed cholecystitis from gall-stones; in other words, the diagnosis will only be arrived at after opening the abdomen, sometimes only after microscopical examination of sections of the gall-bladder, because a thickened and infiltrated gall-bladder frequently resembles, or is accompanied by, carcinomatous infiltration not distinguishable with the naked eye.

The early symptoms are rarely characteristic. There will usually have been a history of gall-stone disease in the past. The patient will complain of loss of appetite and of disturbances of digestion. Actual biliary colic is usually absent. If the disease has existed for several months, the patients may appear cachectic, and will have lost a good deal of flesh. There will usually be a sense of dull pain or oppression in the region of the gall-bladder. After a time a palpable tumor will be present. The tumor usually feels hard; its surface may be nodular or smooth; it is situated in the region of the gall-bladder, and is evidently connected with the liver. In cases not complicated

by infection or empyema of the gall-bladder the tumor will not be especially tender, nor will there be the sign of marked abdominal rigidity.

As the disease progresses jaundice is slowly developed. The progress of the jaundice is steady, not intermittent. As the disease progresses and invades the liver a considerable tumor mass will be formed. The patient will become progressively more and more anemic, emaciated, and cachectic. In the later stages of the disease there may be ascites or cancerous peritonitis. The duration of life is very short, rarely more than a year, and with an extreme limit of life of two years.

The Mayos report forty operations for malignant diseases of the biliary passages. Of these, nine died in the hospital. Two cases of cancer of the gall-bladder remained well after more than two years. In two other cases the outlook appeared hopeful. A few cases only of actual cure are reported by other observers. I have had one successful case, which remains well now at the end of six years.

AUTHOR'S CASE OF CANCER.—John A., policeman, a temperate, healthy man, aged forty-four, entered the New York Hospital, April 4, 1903. He had suffered from attacks of indigestion during the past year. Four months before I saw him he began to suffer from a dull pain in the region of the gall-bladder. The pain was more or less continuous, with exacerbations. Subsequently he began to suffer from attacks of vomiting. His digestion became impaired and he ran down in health. He had lost thirty-five pounds in weight during the last few months, and had slowly become jaundiced during the past few weeks. The jaundice has been constant and slowly progressive, but is now of only moderate intensity. The upper portion of the abdomen is slightly distended and tympanitic. The liver dullness extends one inch below the free border of the ribs. No tumor could be felt. Abdominal rigidity was scarcely noticeable. He was notably anemic. Temperature and pulse normal. There was slight leucocytosis, but the differential count showed nothing distinctive.

The absence of very acute attacks of pain, the more or less continued character of the pain, the marked deterioration in general health and loss of weight, the absence of tenderness and of fever, led me to suspect cancer of the gall-bladder.

April 6, 1903, the gall-bladder was exposed through a four-inch incision. It was rather deeply situated and considerably distended, but not adherent. Upon palpation one could feel that the third of the gall-bladder away from its fundus was occupied by a tumor of considerable size.

The complete removal of the gall-bladder was attended with some difficulty on account of hemorrhage from the liver, in which the gall-bladder was rather deeply embedded. The bleeding was very free, and had to be controlled by temporary packing. After removal of the entire gall-bladder, together with the malignant growth, down to a point opposite the hepatic artery, the wound in the liver was packed and a small drainage-tube inserted.

After removal, the gall-bladder was opened. There was considerable thickening of its walls, and that half of the organ away from the fundus was occupied by the malignant growth; the fundus did not seem to be involved. The gall-bladder contained a few minute stones. The diagnosis of carcinoma could be made with

comparative certainty from the gross appearance of the tumor. The patient made an uneventful convalescence. On May 27, 1903, he had gained over twenty-five pounds since the operation, and there were no evidences of any secondary growths. In April, 1909, this man was still in perfect health, and remained, as he had been, on active duty on the police force.

Tumors of the Gall-ducts.—Both benign and malignant growths are observed in the common bile duct and in the hepatic duct. As a diagnostic entity carcinoma alone will be here considered. The disease occurs at least as often in men as in women, thus differing from cancer of the gall-bladder. The causative relation between gall-stones and cancer of the ducts is thus not entirely clear, although Mayo Robson believes that such a relation does exist in most cases. Primary cancer of the common duct is a rare disease. Among eighteen cases collected by Musser, fourteen were in the common duct and three were in the hepatic duct. The favorite site is at or near the papilla—nine cases. The other sites are at the junction of the cystic and hepatic ducts and at the bifurcation of the hepatic duct. The type of the disease is usually of the columnar-celled variety. Kehr states that scirrhus is the ordinary form, and that the softer forms of carcinoma are extremely rare. Disseminated infection appears to be long delayed. The lymph nodes in the gastrohepatic omentum are the first glands to be involved, but this infection may not occur until late in the disease. In some cases, long after the condition has ceased to be operable, the lymph nodes at the root of the neck behind the clavicle, usually upon the left side, may be found enlarged and hard (jugular gland). The diagnosis of cancer of the bile ducts can rarely be made before operation.

The symptoms closely resemble those of cancer of the head of the pancreas. The gall-bladder is usually distended and enlarged. There is jaundice, which may at first be intermittent, but soon becomes progressive and intense. There are the ordinary digestive disturbances, clay-colored stools, and bile-stained urine of cholemia. There is progressive emaciation, anemia, and debility. A tumor other than the distended gall-bladder is not likely to be felt. There is nothing characteristic about the pain except that it is not apt to be severe, at least not so severe as the pain of gall-stone impacted in the papilla. Septic symptoms may appear from infective cholangitis. The liver in many cases will be somewhat enlarged. The spleen may also be enlarged. The local signs in the vicinity of the gall-bladder are usually rather negative—that is to say, there is not much localized pain and tenderness. Cancer of the papilla has been operated upon with temporary benefit by Halsted, Mayo, and a very few others.

CHAPTER VI

INJURIES AND DISEASES OF THE SPLEEN

THE SPLEEN: TOPOGRAPHICAL AND ANATOMICAL REMARKS ADAPTED FROM MERKEL

The spleen under normal conditions is a soft and elastic, rather fragile, organ, whose shape is largely molded by contact with the surrounding viscera. The form of the spleen is that of a tetrahedron whose base is directed toward the diaphragm and whose apex is turned toward the interior of the belly. The diaphragmatic surface is molded to the shape of the diaphragm, and since the anterior surface exhibits a concavity, the general contour of the spleen is concavo-convex. Beginning at the apex of the tetrahedron, three other surfaces may be distinguished—a gastric, renal, and basal surface. The diaphragmatic surface, the largest, lies beneath the ninth, tenth, and eleventh ribs. The longest diameter corresponds very nearly with the direction of the tenth rib. Behind the diaphragm, and between it and the chest wall, the pleural cavity extends below every portion of the spleen. The lung reaches posteriorly to the level of the eleventh dorsal vertebra, so that the spleen is also partly covered by lung. *A stab wound reaching the spleen through the thoracic wall thus inevitably wounds the pleura, sometimes also the lung.* The gastric surface is in contact with and molded upon the posterior surface of the fundus of the stomach; this contact obtains only when the stomach is full, not when it is empty. The renal surface is in contact with the outer border of the upper pole of the left kidney. The extent of surface in contact with the kidney varies with the position of that organ. The basal surface, the smallest of all, is in contact with the tail of the pancreas and the splenic flexure of the colon. The spleen extends toward the middle line nearly to the border of the eleventh dorsal ver-

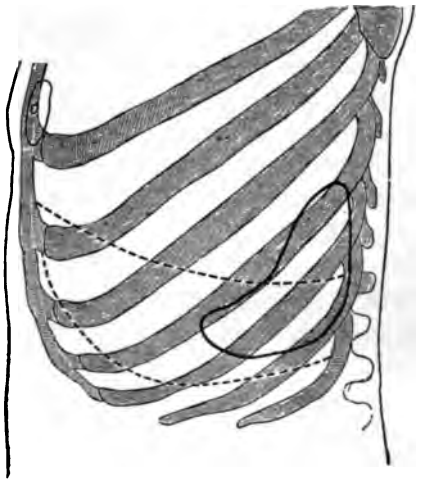


FIG. 27.—POSITION OF THE SPLEEN IN RELATION TO THE RIBS. Viewed from the left side. (Merkel.)

tebra. It may actually touch it, or the separation may be an inch. Laterally the lower part of the spleen usually extends as far forward as the midaxillary line, but not normally beyond a line drawn from the left sternoclavicular joint to the tip of the eleventh rib (the left costoclavicular line). The spleen moves with the diaphragm with respiration, but less so than the liver. The condition of fullness or emptiness of the stomach and colon respectively has some effect upon the position of the spleen. If an individual lies upon the right side of the body, the upper and anterior border of the spleen moves downward and forward a distance of 3 to 4 cm. farther than when the subject stands erect or lies on his back. The spleen cannot be palpated when normal, nor can its limits be made out accurately by percussion except its lower and outer end. As stated, it is partly covered by the lung. The proximity of the kidney, the thick muscles of the back, the condition of fullness or emptiness of the colon and stomach, whether filled with gas or solid or liquid material, are all conditions which render percussion of the outlines of the spleen difficult. The area of splenic dullness may be abolished in emphysema or covered by pleuritic effusions. Tumors of the spleen may displace the diaphragm upward, causing dyspnea. This is more apt to occur in children than in adults, because in the former the phrenocolic ligament affords firmer support to the organ, holding it more firmly against the diaphragm. The size of the spleen in the adult is on the average about five inches in length, three in breadth, and one and a quarter in thickness. The weight of the spleen in the cadaver is from 150 to 200 gms., and a sixth more when filled with blood. Its size varies under different conditions more than any other organ in the body. It is larger in proportion in children, increases in size after eating, and becomes regularly enlarged in a great variety of diseases, notably in febrile conditions, malaria, typhoid, and in many other infectious diseases. The spleen may become so large that it reaches to the pelvis, fills the abdomen, and has been mistaken for pregnancy. Some of the diagnostic characters of a splenic tumor have already been dwelt upon under Diagnosis of Diseases of the Abdomen; others will be mentioned under suitable headings. The spleen is held in place by folds of peritoneum containing firm bands of fibrous tissue. Such a fold passes from the left crus of the diaphragm to the spleen. The suspensory ligament, *phrenosplenic ligament* and the *phrenocolic ligament, sustentaculum lienis*; the latter, passing from the diaphragm to the splenic flexure of the colon, supports the colon, and since the spleen rests upon the colon, supports it also, forming a kind of pocket for its reception. The gastrosplenic omentum, necessarily a loose connection, on account of the movements of the stomach, has but little influence in the fixation of the spleen. The ligaments of the spleen may become relaxed, permitting the spleen to fall down and hang free in the abdomen, supported by its vessels. (See Movable Spleen.) The spleen is surrounded by a firm connective-tissue capsule, which sends connective-tissue septa into the interior of the organ, affording support to the soft and friable parenchyma.

Blood Supply.—The spleen receives for its size a very large supply of blood. The splenic artery runs a tortuous course, from right to left, and divides, before reaching the organ, into from six to twelve branches. These vessels enter the hilum of the spleen, but do not anastomose in its substance. This explains the occurrence of wedge-shaped infarcts in the spleen as the result of the lodgment of emboli in its substance. The splenic vein runs parallel with the artery, is double its size, less tortuous, lies below it, and empties into the portal vein. The multiplicity of the arteries entering the spleen makes it necessary for the surgeon to use great caution when tying off the pedicle in the operation of splenectomy to secure all the bleeding points. The spleen may be reached by a vertical incision in the outer border of the left rectus muscle, or by an incision parallel with the ribs, similar to that used for removing the kidney. It may also be reached by resecting the tenth rib, or the ninth, tenth, and eleventh ribs, if more space is needed, behind the axillary line and passing through the pleural cavity. In some cases this may be a favorable avenue to the spleen in cases of abscess, and especially if the infection has caused adhesions between the diaphragmatic and costal pleura. In tumors of the spleen it is to be borne in mind that the splenic vessels are enormously enlarged, that their walls are thin, and that they are often under considerable tension; great gentleness and care must, therefore, be used in ligating them.

INJURIES OF THE SPLEEN

Injuries of the spleen may be subcutaneous or open wounds. The former may be divided into ruptures and contusions; the latter into stab and gunshot wounds. The subcutaneous injuries are much the more frequent, and injuries of the spleen are five times as frequent among men as among women. Berger collected 467 cases; among these, 308 were subcutaneous injuries by blunt violence; of these, 264 were ruptures, 44 were contusions, 159 were open wounds; of these, 31 were stab and incised wounds, 98 were gunshot wounds, and 31 were cases of prolapse of the uninjured spleen through an external wound. It goes without saying that an enlarged and thickened spleen is much more apt to be ruptured by moderate degrees of blunt violence than is the normal spleen. Thus, in malaria, miliary tuberculosis, typhoid fever, as well as in some other diseases in which the spleen is enlarged and softened, rupture may occur from very slight degrees of violence, even from muscular effort; as, for example, during a violent attack of vomiting. As compared with subcutaneous injuries, stab and gunshot wounds of the spleen are, relatively, very rare indeed. Nearly all the subcutaneous ruptures of the spleen which I have seen in the hospitals in New York—numbering twelve or more—have been produced by "run-over" accidents or by falls from a height. In two or three cases only, from a blow in which the body was struck by a blunt object over the region of the spleen. The illustration represents the spleen of a man who was stabbed in the side and who bled to death from a com-

paratively small wound in the spleen; he was a patient in the Hudson Street Hospital.

The *crushing injuries* of the spleen which I have seen have been of several varieties. In one, a little boy upon whom I operated some years ago in the Roosevelt Hospital, there was a vertical tear an inch in depth through the hilum of the spleen. The main source of the hemorrhage, however, was from one of the branches of the splenic artery, which was torn across just at its entrance to the spleen. The spleen was removed, but the child died of anemia forty-eight hours later. In another case, seen in the service of Dr. Robert Abbe in the Roosevelt Hospital, at which I assisted him in the operation, a little boy was run over by a truck, and was brought to the hospital suffering from the symptoms of shock and hemorrhage. Upon opening the abdomen the lower one third of the spleen was completely separated by a horizontal tear through the substance of the organ. The missing portion of the spleen was found in the right iliac fossa. The right kidney was also extensively crushed and lacerated. In other cases the lower pole of the spleen has been rent more or less deeply or pulpified.

FIG. 28.—STAB WOUND OF THE SPLEEN. Wound of entrance at the lower border of the ninth rib in the posterior axillary line. The wound completely penetrated the spleen. Death occurred from hemorrhage. A larger incision has been made into the spleen to demonstrate the size and depth of the stab wound. The drawing was made for me from the specimen by Dr. B. S. Barrniger. The case occurred in the Hudson Street Hospital and was under the care of Dr. P. R. Bolton.

In cases of contusion of the spleen a hematoma may form in the substance of the organ of varying size; such a hematoma may finally be converted into a mass of scar tissue, or into a cyst, or become impregnated with lime salts, or form an abscess which may burst into the cavity of the peritoneum, or form adhesions with the diaphragm, the stomach, the colon, or the pelvis of the kidney, and thus perforate in one of several directions. The principal dangers of wounds and ruptures of the spleen are *shock* and *hemorrhage*, and, if the patient survives without operation, in some cases peritonitis. It often happens, notably in cases of subcutaneous rupture of the spleen, that associated injuries of a severe character render the condition a hopeless one. About three quarters of the cases of *rupture* of the spleen, untreated, die of shock and hemorrhage within the first twenty-four hours. If not operated upon more than 90 per cent are fatal. As the result of aseptic operation the general mortality

is about 25 per cent. The mortality of gunshot wounds of the spleen is very high—about 60 per cent; that of stab wounds, quite low—10 per cent; that of ruptures—43 per cent (Berger).

Diagnosis of Subcutaneous Ruptures.—The diagnosis of subcutaneous ruptures of the spleen can rarely be made with certainty. After the history of a blow or a fall, etc., over the lower part of the thorax upon the left side, the patients usually, but not always, fall at once into a condition of shock, with which are combined the symptoms of progressive anemia. They suffer from intense abdominal pain, referred to the region of the spleen, becoming later general, as the blood is diffused throughout the abdominal cavity. There will be tenderness and muscular rigidity over the upper right quadrant of the abdomen. Such tenderness and rigidity may remain localized; or in other cases it will become general after a few hours. In some cases there will be dullness on percussion in the right flank, and this dullness may diminish when the patient is made to lie for some minutes upon his right side.

In a certain proportion of cases the blood tends to accumulate in the vicinity of the spleen, so that, if the patient survives for twenty-four or forty-eight hours, a distinct tumor mass will be formed in the upper left quadrant of the abdomen. This condition was present in two cases of rupture of the spleen which I saw in the Roosevelt Hospital. One of them was operated upon by Dr. Charles McBurney, the other by Dr. Frank Hartley. In both a large more or less distinctly localized hematoma was palpable as a somewhat diffuse boggy tumor mass on the left side of the belly below the ribs. In each the spleen was found ruptured; the bleeding had ceased at the time of operation, forty-eight hours or more after the injury. In both the spleen was removed. Both patients recovered.

A certain number of cases of rupture of the spleen show no serious symptoms at the time of the injury. Shock may be absent, and the general symptoms of abdominal bleeding and of peritoneal irritation, severe abdominal pain, vomiting, progressive anemia, etc., may not appear for hours, and may even be delayed for one or two days. Additional symptoms sometimes observed are hoarseness or aphonia, due to injury of the pneumogastric nerve, shortness of breath, immobility of the left side of the thorax, *rarely pain in the left shoulder*. In many instances no diagnosis other than that of intra-abdominal bleeding and shock can be made until the abdomen is opened.

The following case of partial rupture of the vascular pedicle of the spleen by blunt violence is so rare a condition that I insert a brief synopsis of the history:

The patient was a schoolboy, eight years of age, who entered my service at the New York Hospital on November 28, 1908. On the afternoon of admission, while playing in the street, he had been run over by a taxicab. The front wheel of the machine passed over his body on a level with the lower ribs. He got up and walked about five blocks to the nearest police station, whence he was brought by the ambulance to the hospital. Upon admission to the hospital he was pale, perspiring, his

pulse was 112, his respiration 40 and shallow. His abdomen was rigid. There was marked abdominal tenderness over the lower ribs upon the left side and in the left hypochondrium. There were no signs of fractured ribs. Soon after entering the hospital the patient's condition became rapidly worse. His pulse became almost imperceptible. I happened to be in the hospital at the time and made a diagnosis of probable rupture of the spleen with intra-abdominal hemorrhage. I operated upon him at once, making a vertical incision through the belly of the left rectus muscle just below the ribs. The peritoneal cavity contained a large quantity of fluid blood together with clots. The spleen was inspected. It was found that though the spleen itself did not appear to be injured, a large hematoma had formed in its pedicle from which blood was escaping freely. The patient's condition did not permit a prolonged dissection in search of any particular bleeding point, and, therefore, since the child had lost and was still losing a great deal of blood, a ligature was passed around the pedicle mesad to the hematoma and the spleen was removed. There was also a small rupture of the under surface of the left lobe of the liver. This did not bleed sufficiently to require any treatment. The wound was closed in the usual way and the boy made a normal, although somewhat protracted, convalescence. Primary union occurred in the abdominal wound. No very marked anemia developed, and at no time following the operation did the content of hemoglobin fall below fifty-five per cent. Forty-five days after he entered the hospital the child's condition was good. There was slight enlargement of the lymph nodes of the groin and of the axillæ. During the following four weeks he gained six pounds in weight.

FIG. 29.—GUNSHOT WOUND OF THE SPLEEN PRODUCED BY A .38 CALIBER REVOLVER BULLET. The bullet and a piece of clothing which had been carried into the abdominal cavity are shown in the illustration. The spleen was successfully removed by Dr. F. W. Murray in the New York Hospital.

Diagnosis of Stab and Gunshot Wounds of the Spleen.—The diagnosis of stab and gunshot wounds of the spleen must be made from the history of the injury, the situation of the wound, and the relative position—in the case of gunshot wounds—of the orifices of entrance and exit respectively. The signs of intra-abdominal bleeding or of sharp hemorrhage from the external wound. When the wounding has taken place through the thoracic wall the signs and symptoms of left-sided pneumothorax or hemopneumothorax will be present in a considerable proportion of cases. The bleeding from stab wounds is usually much more severe than from gunshot wounds.

Prolapse of the Spleen through an External Wound.—The spleen may be wholly or partly extruded through a wound of the abdominal wall by the muscular contractions of the diaphragm. The organ is so soft and easily molded that it may be pushed through a very small wound. The pressure upon the vessels of the spleen by the wound edges causes the organ to swell rapidly, and this may create an apparent marked disparity between the size of the swollen spleen and the hole through which it was extruded. The diagnosis of the condition is, of course, absolutely simple. Frequently the organ is uninjured, and the bleeding therefore slight. If let alone, gangrene of the spleen, total or partial, is the result, according to whether the whole or only a part of the organ is prolapsed. The diagnosis of contusion of the spleen without rupture of the capsule is hardly likely to be made unless there are associated injuries requiring operation, or unless infection and abscess follow, or, as sometimes happens, the formation of a cystic tumor of the spleen.

ABSCESS OF THE SPLEEN

As already stated, abscess of the spleen may rarely follow subcutaneous injuries. A much more common cause is embolism of the spleen in the course of malignant endocarditis, pyemia, and occasionally as a complication of general infectious diseases, notably typhoid fever and malaria. Centrally situated abscesses of the spleen may produce no symptoms, or no recognizable symptoms until the abscess has caused notable enlargement of the spleen, or has become adherent to and perforated into some adjoining viscus or cavity. If, in the course of pyemia, malignant endocarditis, acute articular rheumatism with cardiac involvement, typhoid fever, or severe malarial poisoning, the patient had the physical signs of a sudden increase in the size of the spleen, accompanied by pain and tenderness and more or less marked septic

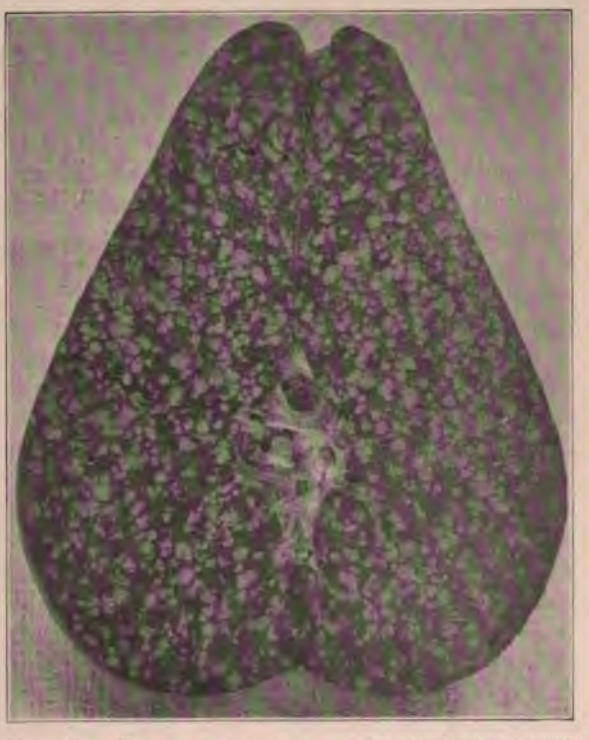


FIG. 30 — TUBERCULOSIS OF THE SPLEEN COMPLICATING TUBERCULOSIS OF THE LUNGS AND OF THE LIVER. Spleen removed at autopsy. (New York Hospital.)

symptoms, our attention would be directed to the spleen, and a probable diagnosis of splenic abscess might be made. In certain cases diffuse suppuration of the spleen has been observed accompanied by severe acute septic symptoms—chills, prostration, a pyemic type of fever, rapid loss of flesh and strength, septic diarrhea, etc. In these cases the disease runs the course of an acute pyemia. In other cases the progress may be slow, and the spleen may reach an enormous size; thus, De Blasi reported, in 1902, a case of streptococcus abscess of the spleen which occurred in a young woman suffering from chronic malarial poisoning. The development of the abscess was slow, and no diagnosis was made until an exploratory puncture was carried out. The patient recovered after two operations. Stoianoff reports a fatal case of abscess of the spleen. The spleen contained six liters of pus. If the abscess perforates into the stomach or colon a diagnosis might be made from the fact that the tumor of the spleen would suddenly diminish in size, and that the patient would vomit a quantity of pus or pass pus in large amount *per rectum* respectively. If the abscess ruptures into the pleural cavity there would be the signs of empyema, or if into the lung the patient would cough up a quantity of pus. If the abscess penetrates the abdominal wall, localized pain, tenderness, induration, edema, and final fluctuation would indicate the nature of the process. It is hardly necessary to state that in case of a suspected abscess of the spleen the introduction of an aspirating needle into the nonadherent spleen would be quite unjustifiable. Actinomycosis of the spleen has been observed.

The following case history illustrates a rare condition coming under my care:

Septic Infarction of the Spleen; Localized Gangrene of the Spleen with Rupture into the General Cavity of the Peritoneum; Diffuse, Purulent Peritonitis. Operation. Death.

J. B., aged thirty-three years, entered the Hudson Street Hospital at two o'clock in the afternoon of May 3, 1906, with the following history: He has always been a healthy, vigorous man, is engaged in manual labor, and has been well up to two weeks ago, when he began to suffer from loss of appetite, moderate prostration, and *pain referred to the left shoulder*, to the left side of the chest, and to the left hypochondrium. He had chilly sensations on several occasions, but no distinct chills. He felt sufficiently ill to give up work, and remained at home and in bed until yesterday. During this time he continued to have more or less pain, but felt so far improved on the day of admission that he went back to his work. At 11 A.M. he was seized with faintness, severe abdominal pain referred to the left side of the abdomen, but without definite localization. His general condition became suddenly much worse, and, as he states, he collapsed and was brought by the ambulance to the hospital. On admission he looked only moderately ill. His pulse was 100; temperature, 101.5° F.; respirations, 26. Blood count showed 26,000 leucocytes. Polynuclear cells, ninety per cent. His abdomen was retracted and everywhere boardlike. The most marked rigidity was over the left rectus muscle, and the greatest tenderness was complained of opposite the umbilicus in the left lower quadrant of the abdomen. He had vomited once in the morning.

The vomiting was not repeated. At 4 P.M. he appeared to be more ill. His pulse was 115; his temperature, 103.5° F.; respirations, 30; condition of the abdomen the same. I saw him at 5 P.M. A diagnosis was made of diffuse peritonitis. No probable point of origin could be determined, except that the location of the focus was thought to be on the left side of the abdomen. A small vertical incision was made in the middle line at the level of the umbilicus. Upon opening the peritoneal cavity a gush of thin pus flowed from among the coils of small intestine. The incision was extended upward and downward. Successively, the small intestine, the large intestine, the appendix, the gall-bladder, the stomach, and the duodenum were inspected. Everywhere there was found an abundant exudate of thin, stinking pus having a putrid odor, which appeared to be distributed throughout the entire cavity of the abdomen; but no lesion was found to account for the process. The greatest quantity of purulent exudate yet seen appeared to come from the region of the spleen, and palpation of that organ showed that it was moderately increased in size. Upon that surface of the spleen lying next to the ribs a cavity in the substance of the organ was entered with the fingers, somewhat larger than an English walnut. The spleen was then inspected, and the cavity was found to be a broken-down gangrenous area with loss of substance. A similar area was found on the anterior border of the spleen, of somewhat smaller size. The entire spleen was very soft and pulpy. Large hemostatic clamps were placed upon the pedicle of the spleen and the organ was cut away, leaving the clamps *in situ*. During the entire operation almost constant irrigations of the peritoneal cavity were kept up by pouring pitchers of hot salt solution into the belly, and a very large quantity of purulent exudate was thus removed. The splenic area was now washed; a large, thick gauze drain was inserted through the upper angle of the wound to the splenic pedicle. The clamps were surrounded by gauze and permitted to project from the incision. Suture of the remainder of the abdominal wound. The patient's condition remained good throughout the operation, although the operative procedures were prolonged on account of the unknown location of the lesion. The patient remained upon the table altogether fifty minutes.

He died at the end of forty-eight hours. The autopsy showed an abscess in the head of the pancreas, and putrid thrombosis of the splenic artery.

CYSTIC TUMORS OF THE SPLEEN

Cysts of the spleen of considerable size have been observed and operated upon containing either serous or blood-stained fluid. It would, of course, be impossible to make an accurate diagnosis of these cysts by any justifiable means other than an aseptic abdominal operation. If small, they will produce no symptoms at all other than the physical signs of more or less marked enlargement of the spleen. If they grow to considerable size they may cause symptoms by pressure upon the diaphragm, the heart, the stomach, intestine, etc.

The *differential diagnosis* between these cysts and cysts of the pancreas, the ovary, the mesentery, and the intra-abdominal cystic tumors must be made, if made at all, by the methods already described under Diagnosis of the Tumors of the Abdomen. Powers (*Annals of Surgery*, January, 1906) collected reports of thirty-two sero-sanguineous cysts of the spleen, including a case of his own.

The etiology appears to be obscure. Ten cases were treated by splenectomy; all recovered.

Echinococcus of the Spleen.—Echinococcus cysts of the spleen are very rare indeed in the United States. In the statistics of echinococcus disease, echinococcus of the spleen has been observed in about three per cent of the cases, although statistics gathered from different sources vary upon this point. The cyst may develop within the center of the organ, producing a general cystic enlargement of the spleen; or upon the surface, producing a more or less completely pedunculated tumor. The cyst is, like echinococcus of the liver, tense and firm; fluctuation can usually be detected, jellylike vibration very rarely. If, as happens also in the liver, the cyst wall becomes greatly thickened fluctuation may be absent. The connection of the cyst with the spleen can usually be made out by palpation and percussion, and by the characteristics of splenic tumors, as already described. Confusion may arise between malarial spleen or a solid tumor or cystic condition of the kidney. In the one case the absence of a malarial history, in the other the physical signs distinguishing renal and splenic tumors, as described, and the absence of urinary symptoms and of changes in the urine, together with the very slow growth of echinococcus, should suffice for differentiation. The symptoms produced by echinococcus of the spleen are those of pressure when the tumor has reached a large size, dyspnea, digestive and intestinal disturbances. If infection occurs, the tumor will increase in size, become tender and painful, and septic symptoms will occur. Rupture into the stomach or colon is followed by vomiting of fluid or of small cysts, or their passage *per rectum*, and diminution of the size of the cyst of the spleen. Rupture into the lung has been followed by death. Rupture into the peritoneal cavity is followed by peritonitis and death, or by disseminated echinococcus of the peritoneum, usually fatal.

SOLID TUMORS OF THE SPLEEN

Leukemic Spleen.—The leukemic spleen has never been removed with benefit to the patient. Most of the cases have died at once or very soon after the operation. None have lived for a long time thereafter, and of those who have lived a few months, none have been benefited. The operation is therefore unjustifiable in this disease. (For the blood changes and pathology of leukemia, see works on general medicine.)

Enlarged Spleen.—The enlarged spleen has been removed many times successfully for malarial enlargement, as well as for simple hypertrophy. A few times for tuberculosis and syphilis. It has also been removed for splenic anemia and for primary splenomegaly. (For description of cases of this condition, see Bovaird, *American Journal of the Medical Sciences*, October, 1900, and Brill, *idem*, April, 1901.) When contemplating the removal of a large spleen, leukemia should be carefully excluded by the examination of the blood; nor should the spleen be removed unless it is causing annoying symptoms, on

account of its size, by pressure and weight; nor in the presence of profound anemia or cachexia. The recognition of the splenic tumor is usually easy, unless it is displaced and adherent. (See Diagnosis of Abdominal Tumors.)

Benign and Malignant Tumors of the Spleen.—A variety of benign and malignant tumors have been observed in the spleen in comparatively rare cases. Thus fibroma, myxoma, enchondroma, lipoma, angioma, dermoid cyst, as well as cases of sarcoma and of true cancer. None of these conditions are of great surgical interest; they are all of them extremely rare, except carcinoma, which may occur as a metastatic tumor here as elsewhere. A few cases only of sarcoma of the spleen have been operated upon, and none of them with very cheering results. The diagnosis of sarcoma of the spleen would depend upon the presence of a rapidly growing tumor of the spleen, hard or soft, and probably of an irregular or knobby contour, of pain in the region of the spleen, and, later, in the development of more or less marked cachexia. The occurrence of primary carcinoma of the spleen is perhaps doubtful. The diagnosis could scarcely be made except by an operation.

Amyloid degeneration of the spleen and the enlargements of the spleen, which occur as the result of heart disease, and to interference with the portal circulation, as in cirrhosis, etc., are not amenable to surgical treatment.

MOVABLE SPLEEN, FLOATING SPLEEN, WANDERING SPLEEN

Relaxation of the ligaments of the spleen permits it to descend a greater or less distance in the abdominal cavity. Such relaxation may occur as the result of an increase in size and weight of the spleen or as the result of a general relaxation of the supporting structures of the abdomen in cases of general enteroptosis. The condition is much more frequent in women than in men, and is commonly observed in females who have borne many children and whose abdominal walls are flabby and relaxed. It is believed by some observers, denied by others, that sudden trauma may be responsible for the immediate production of a movable spleen. The increased mobility of the spleen usually comes on slowly and varies in degree; in extreme cases the spleen may descend into the pelvis; occasionally such a spleen may become fixed in its new position by adhesions. Tension upon or torsion of the vessels of the spleen may lead to atrophy, more rarely to necrosis of the organ, with a resulting peritonitis. Usually, on account of interference with its venous circulation, such a spleen is in a state of chronic congestion and enlargement. In a few cases the spleen, having dragged the tail of the pancreas after it, sufficient pressure has been produced on the bowel to cause obstruction of the duodenum (Delafield and Prudden). The commonest position taken by floating spleen is in the left iliac fossa, less commonly in the central region of the abdomen.

The *diagnosis* of floating spleen depends upon the absence of normal splenic dullness and the presence, usually in the lower part of the belly upon the left side, of a movable tumor having the shape of the spleen. The hilus is usually

directed upward. In some cases it has been possible to feel the pulsatio the splenic artery through the abdominal wall. The characteristic mobili movable kidney, as already mentioned, and the different shape of the t usually suffices to distinguish it from a floating spleen. If the spleen bec adherent, notably when it lies in the pelvic cavity, it is likely to be mist for a variety of other tumors. Sudden torsion and strangulation of the pe of the spleen is attended by violent abdominal pain, nausea, and vomi and the presence of a tumor and the signs and symptoms, in some case peritonitis. In these cases the previous history of the presence of a mo tumor recognized as the spleen will greatly aid in the diagnosis.

CHAPTER VII

INJURIES AND DISEASES OF THE PANCREAS

ANATOMICAL RELATIONS

The pancreas is a retroperitoneal organ. It lies in the epigastric and left hypochondriac region, behind the stomach and lesser sac, and between the duodenum on the right and the spleen on the left. It crosses the median line in front of the first and second lumbar vertebræ from two inches and a half to five inches above the umbilicus. It is in close relation with the posterior wall of the stomach, the transverse colon, the left kidney, and behind it lie the great blood-vessels of the abdomen. The pancreas measures from 12 to 14 cm. in length and 4 to 5 in breadth; it is an elongated organ, and is commonly described as having a head, neck, body, and tail. It weighs from 60 to 100 gm. It stretches transversely across the belly. The expanded head rests in and fills the concavity of the duodenum, and the lower border of the pancreas is in contact with the duodenum as far as the duodeno-jejunal flexure. The head of the pancreas bears on either side a tongue-shaped projection; the lower of these is much the larger; it passes along the inferior flexure of the duodenum, forming a sort of bent hook (the uncinate process), which lies in immediate contact with the superior mesenteric vessels. The body of the pancreas extending toward the left adapts itself to the shape of the stomach in front and the posterior abdominal wall behind. Thus it projects forward, in front of the spinal column, and then bends backward in a slight concavity to the anterior surface of the left kidney. A portion of the pancreas sometimes extends a little above the lesser curvature of the stomach, just at the median line. The anterior surface of the pancreas receives a smooth covering of peritoneum through which the grayish-red lobulated structure of the gland itself is readily visible. The pylorus of the full stomach lies in front of the neck of the pancreas. The splenic vein and artery lie in grooves behind and above its upper border. The pancreatic duct, or duct of Wirsung, commences near the tail of the pancreas, and passes from left to right; at the neck of the gland it turns slightly downward and backward and unites near the head of the pancreas with the common bile duct, forming the so-called ampulla of Vater. The distance from the junction to the papilla of the duodenum is about 8 mm. Thus, a gall-stone impacted in the papilla may obstruct the common duct and the pancreatic duct, so that bile may enter the pancreas and cause

irritation, or, if infected, inflammation, necrosis, etc., of the gland. A second duct—the duct of Santorini—is usually present, and in about half the cases examined appears to be large enough to carry the secretion of the pancreas to the intestine. It leaves the main duct before its union with the bile duct, passes behind the latter, and enters the duodenum about an inch above the opening of the papilla; thus, obstruction of the papilla does not necessarily prevent the entrance of the pancreatic secretion into the duodenum. The deep situation of the pancreas—lying hidden in the depths of the abdomen, completely covered and surrounded by organs and vessels of vital importance and delicate structure—makes it rather inaccessible to the surgeon's art; still, a fairly adequate approach to the pancreas is possible from several directions. First, by entering the lesser sac through the gastrocolic omentum between the stomach and the colon access may be gained to the entire pancreas without dividing any important vessels. Second, by dividing the gastrohepatic omentum above the lesser curvature of the stomach access may be gained to the portion of the pancreas lying in front of the spinal column. This mode of approach does not permit easy access to the head or tail of the organ. Third, by raising the omentum and transverse colon and making an opening in the transverse mesocolon, as in the operation of posterior gastro-enterostomy. This avenue has the disadvantage that by a free horizontal division of the mesocolon important vessels may be divided imperiling the nutrition of the colon. Fourth, by blunt separation of the duodenum in its descending portion from the posterior abdominal wall, the posterior surface of the head of the pancreas may be explored readily—in most cases without injuring any important structure, and in several cases where the author has used this method in seeking for a stone in the common duct, without any considerable bleeding. Fifth, the pancreas may be approached from an incision in either loin parallel to the ribs, stripping up the peritoneum to the necessary extent. This avenue gives only a limited access to the head and tail of the pancreas respectively. It is perhaps only suitable for those cases in which an abscess in the head of the pancreas has perforated the capsule and invaded the retroperitoneal structures of the right loin. As will be pointed out in speaking of cysts of the pancreas, the tendency is for the enlargement to grow into the lesser peritoneal sac, and as the tumor increases in size it may displace the surrounding viscera in such a manner as to approach the abdominal wall above the stomach, or between the stomach and the colon, or below the colon, or, more rarely, as in one case of my own, a cyst of the pancreas presented in the left flank beneath the border of the ribs in precisely the situation of a cystic tumor of the kidney. Still more rarely such a cyst may grow to the right and present beneath the ribs on the right side. The surgeon will therefore adopt, in the individual case, the avenue of approach most direct and easiest under existent conditions.

In the diagnosis of injuries and diseases of the pancreas the qualities of the physiological secretion of the gland are of interest. The secretion of the pancreas is a clear, colorless, sticky fluid, of an alkaline reaction, and of a

specific gravity of 1.030, or thereabouts. It contains much albumin; its concentration, however, varies much under normal conditions. It is believed to contain at least four ferments—a diastase ferment, an emulsifying ferment, a fat-splitting ferment, and a ferment which converts albumin into peptone. The action of some of these ferments is notably increased by admixture with the intestinal juice. It is at present believed that leakage of the pancreatic secretion into the peritoneal cavity may cause irritation of the peritoneum amounting to an aseptic peritonitis, and, further, that a mixture of blood and of pancreatic secretion prevents the formation of peritoneal adhesions, and in the presence of even a small number of pyogenic bacteria favors the occurrence of a septic peritonitis (Mikulicz). It has, moreover, been observed that inflammations of the pancreas and wounds of the pancreas in which the pancreatic secretion escapes into the peritoneum are frequently accompanied by necrosis of the fatty tissues, sometimes of limited extent and sometimes very extensive. The practical lesson to be drawn is that in accidental wounds of, and surgical operations upon, the pancreas an adequate drainage should always be provided for the escape of the pancreatic secretions. It has been discovered that in animals removal of the pancreas is usually followed by diabetes, and wounds and diseases of the pancreas in man are sometimes, but not always, followed by the appearance of sugar in the urine. The injuries and diseases of the pancreas offer in a large proportion of cases great difficulties in diagnosis. The injuries of the pancreas are comparatively rare, and are nearly always associated with very serious injuries of other structures, and it has happened in a large proportion of the cases, whether of contusions of the abdomen or of gunshot wounds, that the injury of the pancreas has not been discovered at the time of the operation, but only after the death of the patient. The reasons for this are that injuries of the pancreas present no distinctive diagnostic symptoms at all, and that the associated injuries are so severe that by the time the wounds of the stomach and intestine or liver or of other viscus have been treated, the condition of the patient has become so grave that the pancreas is rarely inspected. In diseases of the pancreas also it happens that nearly all the symptoms accompanying pancreatic disease may be produced by other causes than disease of the pancreas itself. Thus, the discovery of sugar in the urine may in some cases when concomitant symptoms exist lead to a suspicion of pancreatic disease, but by no means to a certainty, since the pancreas may be extensively diseased or destroyed without the appearance of sugar in the urine; and in autopsies upon the bodies of those dead of diabetes the pancreas frequently appears normal. Neither is the appearance of free fat in the stools a positive indication of disease of the pancreas. We have already discussed under diseases of the biliary passages the symptoms produced by obstruction of the common duct below the papilla, among them is jaundice. But rarely is the symptom jaundice accompanied in these cases by other signs or symptoms which permit us to make a positive diagnosis of pancreatic disease. The symptom pain in the epigastrium present in many cases of disease of the

pancreas, whether acute or chronic, offers nothing distinctive either in its character or localization. Even the presence of a considerable tumor of the pancreas cannot always be identified as an affection of that particular organ until the abdomen is opened. We have already spoken of the frequency with which gall-stone disease is accompanied with or followed by a chronic inflammation of the pancreas.

INJURIES OF THE PANCREAS

Injuries of the pancreas may be subcutaneous injuries or open wounds. They rarely occur alone, but, as stated, are almost always associated with other grave intra-abdominal lesions. Such injuries as commonly produce rupture of the liver, rupture of the spleen, or rupture of the kidney may also cause rupture of the pancreas, or crushing injuries in the epigastrium in which, as when an individual is caught between the buffers of a railway train, powerful compression of the body in the epigastrium takes place, such that the pancreas, among other organs, may be crushed or torn against the spinal column. As stated, it is one of the possibilities that a stab or gunshot wound of the anterior abdominal wall might, notably in cases of downward displacement of the stomach, reach the pancreas and cause a wound without injuring any other important organ. Such an occurrence would, however, be extremely rare. The symptoms of subcutaneous injuries of the pancreas are simply those already described as common to rupture of the intra-abdominal viscera. That is to say, the symptoms of shock and hemorrhage; and there is no distinctive sign except the situation of the wound in the epigastrium which might lead us to infer that the pancreas was injured. There are also the signs and symptoms of peritoneal irritation, a tender, rigid abdominal wall, pain, etc.

The only practical rule to be given in regard to ruptures of the pancreas is that when the surgeon operates for a serious subcutaneous injury of the upper part of the abdomen, it is always a wise precaution to inspect the pancreas. In those cases of subcutaneous rupture of the pancreas which have been operated upon soon after the injury was received the amount of hemorrhage from the torn pancreatic tissue has usually been small. If the patient is not operated upon at once a variety of complications may follow; the injury to the pancreas may give rise to a pancreatic cyst; to a hematoma of the pancreas and the formation of a cystlike tumor in the pancreas itself; or the formation of a hematoma in the lesser peritoneal sac; or to abscess of the pancreas; necrosis of the pancreas, or to peritonitis—all of which will give more or less characteristic signs and symptoms.

Open Wounds of the Pancreas.—Stab and gunshot wounds involving the pancreas alone without injuring any of the surrounding viscera or blood-vessels are possibilities, although extremely rare, nearly all of these being combined with injuries of other organs. Küttner reported a case of a stab wound of the stomach, involving also the pancreas, in which by immediate

suture of the wounds of the stomach and of the pancreas he was able to save the patient's life.

GUNSHOT WOUNDS OF THE PANCREAS.—While gunshot wounds of the pancreas no doubt occur with considerable frequency, yet the number of cases reported in the literature is comparatively small. F. G. Connell (*Annals of Surgery*, May, 1905), in a paper in which he had collected the reported cases and added one case of his own, found but twenty cases in the literature of the subject all told; and in no single one of them were there any signs and symptoms after the injury at all suggestive of a wound of the pancreas except the situation of the wound in the abdominal wall and the general course of the bullet. In wounds involving the posterior wall of the stomach, or entering the lesser sac from any direction, the surgeon should inspect the pancreas. Among the twenty cases reported there were eleven deaths and nine recoveries. In six of the cases not operated upon all died. There was one case not quite properly included in the list, the nature of which was as follows: This was a gunshot wound of the right side of the abdominal wall, through which, two days after the injury, a portion of the pancreas prolapsed. A silver wire was tied around the projecting portion, and eventually the ligated part was snipped off with a scissors. The patient recovered. Twelve cases were operated upon, seven recovered and five died. In nearly all there were serious associated injuries sufficient to cause death, irrespective of the wound of the pancreas. In three of the twelve cases the injury of the pancreas was not found until after death. In nine cases some operative procedure was done upon the pancreas; of these, two died and seven recovered. The conclusions drawn by the author of this article, in which he agrees with R. Park, are that gunshot wound of the pancreas is almost certain to be followed by leakage of pancreatic fluid; that the wound of the pancreas should be sutured whenever practicable; that drainage should be instituted in every case, best by a combination of rubber tube and gauze drainage, and that this drainage should, if possible, be led out through the posterior abdominal wall. Among the twenty cases fat necrosis was observed but twice, and that only at autopsy. Further, in regard to wounds of the pancreas, it is to be borne in mind that while, as stated, bleeding has not usually been found excessive after contusions and subcutaneous lacerations of the pancreas, yet following incised and gunshot wounds the hemorrhage from the pancreas may be very profuse. The pancreas is a very vascular organ, and there does not seem to be the same tendency toward spontaneous stopping of the bleeding as obtains elsewhere in the body.

As already mentioned, a few cases have been observed where a portion of the pancreas has prolapsed through a wound in the abdominal wall. On account of the immobility of the organ this is a rare happening. The only mistake in diagnosis possible would be to suppose that a piece of omentum was pancreatic tissue or vice versa.

THE DISEASES OF THE PANCREAS

Pancreatic Apoplexy.—Spontaneous hemorrhages in the substance of the pancreas, sometimes of large size, leading to destruction of or necrosis of the gland, are observed occasionally. The patients are usually of middle age; they are often obese; they are sometimes chronic alcoholics. The disease comes on very suddenly with the most violent symptoms, and is nearly always fatal. It is rare that the condition of these patients is such that any operative interference can be thought of. The history of such a case is that an individual apparently in normal health, or who may have suffered from attacks of indigestion, is suddenly seized with a violent pain in the pit of the stomach with repeated vomiting, and falls into a condition of collapse, from which he does not recover. If the patient survives for some hours or a day, there may be the formation of a tumor or of a diffused sense of resistance in the epigastrium. In some of the cases the remaining tissue of the pancreas has been found normal after death; in some a state of fatty necrosis or degeneration of the walls of the blood-vessels has been noted. A few of these cases may survive and become the subjects of a secondary operation for drainage. Cultures made from the hemorrhagic exudate in the peritoneum and from the pancreas itself have been found sterile in a number of instances; and it is believed that these cases are to be separated pathologically from the forms of acute inflammation of the pancreas attended by hemorrhage, because in this latter condition bacterial infection is usually present.

Inflammations of the Pancreas.—Under this head we may include hemorrhagic pancreatitis, suppurative pancreatitis, necrotic pancreatitis, incidentally the necrosis of fatty tissue, which is a concomitant of acute inflammation of the pancreas, and chronic interstitial pancreatitis. The acute inflammation of the pancreas with the formation of abscess may be a part of a general pyemic process or occur in the course of any of the acute infectious diseases: small-pox, typhoid fever, etc. Such cases are rarely suitable for operation. Inflammation may further be caused, as already noted under Gall-stone Disease, by plugging of the papilla in the duodenum and the entrance of infected bile in the pancreatic duct. This is believed to be the most frequent avenue of infection. Robson states that inflammations of the pancreas are, in his belief, due to the same causes as inflammations of the gall-bladder. The presence of calculi in the pancreatic duct is no doubt a condition favoring infection, although a rare one. Unquestionably trauma plays an important part in inflammations of the pancreas, and apparently the inflammation may recur as the result of a slight injury at quite a remote date. Spontaneous bleeding in the substance of the pancreas may also result in inflammation. As already noted, pyloric or duodenal ulcer may penetrate and infect the pancreas.

Acute Hemorrhagic Pancreatitis.—The lesion of acute hemorrhagic pancreatitis appears to be characterized in most cases by an infiltration of the substance of the gland with blood, sometimes the formation of disseminated

hematomata in the gland, associated with degeneration and necrosis of the organ, and bacterial infection, most often with Bacillus coli communis. It is probable that acute hemorrhagic pancreatitis simply represents an exceedingly acute form of inflammation. Mikulicz regarded acute pancreatitis as an acute phlegmon which, on account of the peculiar nature of the tissue, runs an unusually severe course. The great majority of patients who suffer from this disease die very soon. If they survive for days, the condition may eventuate in an abscess of the pancreas, either disseminated or more or less distinctly localized, or they may suffer from gangrene of the pancreas or from diffuse peritonitis. There are, however, milder cases, apparently, in which either spontaneously or as the result of treatment the process may be arrested and cure result. This is probably not true of the cases running a very acute course. The disease occurs mostly in men in middle life. It begins suddenly with violent epigastric pain, is accompanied by severe and repeated vomiting, frequently by hiccough. There is boardlike rigidity of the upper part of the abdomen and extreme tenderness on pressure; the symptoms of collapse frequently come on in a few hours. The patient has a subnormal temperature, an exceedingly rapid, feeble pulse, and cyanosis is often observed; the extremities are cold, the body is bathed in a clammy sweat. Death usually occurs in from twenty-four hours to five days. This train of symptoms, while in no wise characteristic, may be suggestive of pancreatic inflammation if the patient has suffered from gall-stones, if he is obese, if he suffers from general arterial sclerosis, if he is a chronic alcoholic, or if there is a history immediate or remote of an injury to the upper part of the abdomen. A history of gall-stone disease is present in a large proportion of these cases, the occurrence of sugar in the urine and of fat in the stools is inconstant, and cannot be regarded as of much diagnostic value. Sugar, if present, appears early. The disease with which acute pancreatitis is most often confounded is obstruction of the bowel high up, and although a positive differential diagnosis is scarcely possible, yet the symptoms of intestinal obstruction do not in the majority of instances come on with the absolute suddenness attending acute pancreatitis. The condition of collapse is apt to be longer delayed in intestinal obstruction, nor is the obstruction in pancreatitis always absolute; some gas may be passed *per rectum*, and as the result of enemata the bowels sometimes finally move. Moreover, at the beginning of acute pancreatitis the abdomen is usually boardlike and retracted, the scaphoid abdomen; in some cases moderate tympanitis has been observed. In these cases the picture of the disease is identical with perforative peritonitis due to ulcer of the stomach or duodenum. The history may aid in the differential diagnosis, usually in perforative peritonitis there will be a history of gastric disturbance, possibly of the vomiting of blood or passage of tarry blood with the stools. The following case of acute hemorrhagic pancreatitis, upon which I operated a few months ago, may fairly serve to illustrate the difficulties of diagnosis, and is perhaps a typical picture of the disease: A healthy, vigorous, well-nourished man of forty-six years of age was brought to the

Hudson Street Hospital with the following history: He had, he believed, been quite well until eighteen hours before admission. There was no history of biliary colic, of jaundice, or of gastric disturbances. He had suddenly been seized with an excruciating pain in the upper part of the belly, followed by vomiting and great weakness. The symptoms continuing, he was brought to the hospital in the ambulance. When I saw him he looked severely ill; his face was anxious, he vomited at frequent intervals a bile-stained brownish fluid. His temperature was 99° F., his pulse 110 and of poor quality. The abdomen was retracted—the typical scaphoid abdomen. He referred the pain distinctly to the epigastric region. There was extreme tenderness on pressure; most marked midway between the umbilicus and the ensiform cartilage. The diagnosis was made of a probable perforation of an ulcer of the stomach or duodenum. Upon opening the abdomen the peritoneal cavity was found to contain a moderate quantity of thin blood-stained fluid; fat necrosis was not observed. Inspection of the pancreas showed that the head of the pancreas was greatly swollen, of a dark purple color. There appeared to be no gross perforation of the peritoneum overlying the pancreas, but beneath this layer an extensive hematoma could be seen in the retroperitoneal tissue. The entire pancreas was hard and greatly swollen. Irrigation of the abdomen with hot salt solution. Drainage. Death in forty-eight hours without relief of the symptoms. At the autopsy disseminated plaques of a white or yellowish-white color were noted in the fat of the omentum in the retroperitoneal tissues and in the mesentery; they varied in size from the head of a pin to that of a split pea.

To summarize briefly the symptoms of the most acute cases; they are very sudden and very violent pain in the central part of the abdomen, repeated vomiting, a rigid and tender belly, absolute constipation, a normal or subnormal temperature, rapidly progressive collapse with a greatly accelerated and feeble pulse, ending in death in from twenty-four hours to four or five days.

In some cases a diagnosis of perforative appendicitis, of perforation of the gall-bladder, or simply of diffuse peritonitis, has been made. Upon opening the abdomen the presence of a blood-stained exudate, and more especially the presence of minute plaques of fat necrosis, will lead the surgeon to examine the pancreas. It is important that the diagnosis of pancreatitis should be made as soon after opening the belly as possible, since these patients do not bear a prolonged operation. Such, for example, as evisceration or inspection of the entire intestine in search of an obstruction. Nearly all these cases operated upon early who have survived have been subjected to a simple procedure—irrigation of the belly with 0.9 per cent salt solution and drainage. In the less desperate cases one or more incisions may be made in the swollen pancreas for the relief of tension, and drainage (Mikulicz, Porter). The diagnosis of the less acute cases of pancreatitis in which the patients survive long enough to develop a localized abscess, a general peritonitis or necrosis of the pancreas is even more difficult, as will be explained in the following paragraphs.

It seems probable that the most rapidly fatal cases of hemorrhagic pancreatitis represent a very intense infection, and that the cases of necrosis of the pancreas and some of the cases of abscess are less violent forms of a similar process.

Suppurative Pancreatitis, Abscess of the Pancreas.—As already stated, the most frequent avenue of infection is through the pancreatic duct from the biliary passages, hence a history of gall-stone attacks is often obtainable. Any of the pyogenic microbes may be present. Bacillus coli is the form most often found. The purulent infection of the gland may be diffuse, leading to purulent softening of the entire gland, and necrosis, or there may be disseminated foci of suppuration, or a single abscess. Owing to the presence of Bacillus coli, the pus often has the odor of putrefaction. The suppurative process beginning in the pancreas nearly always penetrates its capsule and invades the surrounding structures, and the direction in which this invasion takes place will determine to a considerable extent the clinical signs and symptoms in the given case. Thus if the infection continues retroperitoneal, a localized abscess or phlegmonous inflammation may occur in either loin. Such cases may exactly simulate suppuration around the kidney (F. T. Brown). Perforation into the lesser sac will produce an empyema of this space, forming an acute inflammatory tumor in the epigastrium behind the stomach which may approach the anterior abdominal wall (this localization affords the best opportunity for a diagnosis); above the lesser curvature, or below the stomach and above the colon. In other cases a left-sided subphrenic abscess results. Actual perforation through the skin is rare. A number of cases of perforation into the stomach and intestine (colon) have been reported. Perforation into the free cavity of the belly causes diffuse peritonitis, usually associated with fat necrosis. In some cases hepatic pyemia with multiple abscesses in the liver and its accompanying symptoms has occurred. (See Liver, also Septic Portal Thrombophlebitis.) The abscess may burrow down the psoas sheath even into the pelvis, or into the right iliac fossa (F. W. Murray). The local signs therefore will vary a good deal in different cases. The disease may run an acute or subacute course. In the acute cases the patient is seized with severe pain in the upper part of the abdomen, vomiting, prostration, sometimes chills occur, there is an elevation of temperature of a septic type (remittent), a rapid pulse, a leucocyte count characteristic of suppuration, localized tenderness and rigidity above the umbilicus, sometimes, as stated, the formation of a distinct tumor mass, or a sense of resistance, and localized tympanites. As in all acute peritoneal infections, the retracted, scaphoid abdomen is the first expression of an intense peritoneal irritation, tympanites follows from paresis of the gut after actual peritonitis has time to develop. Inflation of the stomach and colon may be useful in establishing the deep situation of the lesion. The digestive disturbances are usually marked. The patient emaciates rapidly. The original constipation gives place to a septic diarrhea. Sugar may or may not be found in the urine. The absorption of fats and digestion of meat fibers may be so far interfered with that the stools may give a valu-

able hint as to pancreatic disease. According to Fitz, free fat occurs almost exclusively in those cases associated with liver disturbance. In twenty-nine cases where free fat was found jaundice was present in twelve. In general the picture is that of a more or less intense sepsis with a localization which varies as described. In the less acute cases the septic symptoms will only be slowly developed. The individual will suffer from attacks of pain or from continuous pain in the epigastrium with loss of appetite and vomiting. In the course of days or even weeks septic symptoms, peritonitis, a localized inflammatory tumor, will become manifest, often a septic fetid diarrhea.

Necrosis of the Pancreas.—Necrosis of the pancreas follows infection through the bile passages, or may, as already stated, occur as the result of open or subcutaneous wounds, or a spontaneous hemorrhage into the pancreas, or the death of the gland in whole or in part may simply be a more advanced stage of an acute or hemorrhagic pancreatitis. Whether the condition ever begins as a purely aseptic process except in the cases of pancreas apoplexy, it is hard to say, but certain it is that infection nearly always is found in the cases which die or are subjected to operation. The necrosis is often associated with a phlegmonous inflammation of the surrounding structures. In some cases the gland has simply been found as a putrid, green or black retroperitoneal slough. Cases have been observed in which a portion of the necrotic pancreas has been discharged *per rectum* through perforation into the colon. Clinically it is not possible to distinguish between the suppurative and necrotic varieties of pancreatitis. In the latter group there is apt to be a sudden violent onset, as already described. Pain, vomiting, constipation, etc. The patient does not, however, die at once. The acute symptoms become less violent, but the patient after some days becomes septic. The digestion and nutrition suffer severely, and a more or less characteristic inflammatory focus develops, as described under the suppurative form of the disease.

Chronic Interstitial Pancreatitis.—A chronic indurating form of pancreatitis is observed quite often when operating for gall-stone disease. It is due in a very large proportion of cases to a mild but frequently repeated infection from the biliary passages, and this is favored by obstruction of the papilla by stone, by a tumor, usually a carcinoma, by repeated attacks of inflammation (ulcer of stomach or duodenum). Repeated attacks of gastroduodenitis. A stone in the pancreatic duct itself will produce a similar condition. Typhoid infection of the pancreas has been observed in some cases long after recovery from the fever (two years) (Moynihan). Chronic alcoholism may produce an interstitial inflammation of the pancreas as of the liver; syphilis may do the same, also tuberculosis and arteriosclerosis. Gall-stones being by far the commonest associated lesion, it is found that the two conditions correspond fairly in the date of their occurrence—i. e., two thirds of the cases occur between the ages of forty and sixty years. It is rarely if ever possible to make an early definite diagnosis of chronic interstitial pancreatitis to the exclusion of gall-stone disease, or even of cancer of the pancreas until the abdomen is opened,

and not always then, with certainty, since the swollen indurated head of the pancreas cannot be distinguished from an early stage of carcinoma by inspection or palpation. In two cases I was able to establish the diagnosis positively of cancer in one and of pancreatitis in the other, by cutting out a small portion of the indurated head of the pancreas for microscopic examination before closing the abdomen. In both cases gall-stones were present. The cancer case died in a few months; the other patient remains in good health. In advanced cases of cancer a palpable tumor may be felt; the jaundice, emaciation, anemia, and cachexia are rapidly progressive.

Symptoms.—As stated, the symptoms of chronic interstitial pancreatitis are, as far as they can be referred to disturbances of the function of the gland itself, somewhat indefinite. In a large proportion of the cases there will be a history of gall-stone disease; in many the group of symptoms attending chronic obstruction of the common duct will be present, such may be due to the actual presence of a stone in the papilla, or to obstruction of the duct from pressure of the hard and swollen head of the pancreas. In all cases not producing more urgent symptoms there will be disturbances of digestion; sometimes constipation, sometimes diarrhea; there may be a more or less constant sense of oppression or dull pain in the epigastrium. Attacks of acute pain may also occur; there may be symptoms of compression of the duodenum. (See Duodenum.) The nutrition of these patients gradually fails. From time to time there may be attacks of jaundice and distention of the gall-bladder. In very thin persons it may be possible to palpate the enlarged head of the pancreas through the abdominal wall. The condition so closely simulates cancer of the head of the pancreas on the one hand, and obstruction of the common duct by a stone on the other, that, as stated, the lesion is usually first definitely made out when the abdomen has been opened. No matter which of the three lesions is found the surgeon is justified in making the operation.

During the past few years the diagnosis of pancreatic disease has received much attention on the part of surgeons and pathologists, and numerous laboratory methods have been devised in the effort to render the diagnosis of pancreatic disease more certain. At the outset it may be stated that none of the tests proposed are as yet so uniformly positive in the presence of pancreatic disease that they can be relied upon with entire confidence in the individual case. The mere presence of glycosuria is in no wise distinctive of disease of the pancreas, nor is it possible to assert in the given case that the presence of sugar in the urine is due to a faulty action of this organ. One of the simplest tests for the determination of the presence or absence of pancreatic activity was devised by a man by the name of Mueller. It cannot as yet be pronounced absolutely reliable. The test is as follows (*Surgery, Gynecology, and Obstetrics*, December, 1908, A. J. Ochsner, page 622):

The patient is given a test meal and two hours later a calomel purge. A few drops of the stool are sterilized by heating to a high temperature and then placed

on an agar plate containing Loeffer's serum. This material is kept at a temperature of 131° to 141° F. for twenty-four hours. If trypsin is present the serum shows pronounced depressions where this substance has been active; if absent the serum remains smooth.

Another laboratory test which has attracted much attention is the one devised by Cammidge, of London. Cammidge published in 1904 the results of his investigation, and stated that he had been able to isolate from the urine of patients suffering from pancreatitis a substance which he believed to be characteristic and of great diagnostic importance. Others who used his first method met with disappointment, and he has since twice modified it. His third method, or "C" reaction, is at present regarded as of considerable diagnostic value, although the same reaction has been obtained in other conditions, notably in tuberculosis of the peritoneum, cancer of the stomach, and some other conditions. The negative value of the test is probably greater than its positive value.

The substance isolated in the reaction is "pentose," a body closely related to the sugars but not identical with them. The Cammidge test is thus described by Schroeder, of Cincinnati (*Surgery, Gynecology, and Obstetrics*, December, 1908, J. Henry Schroeder, "Physiology and Chemical Pathology of the Pancreas in Pancreatitis," page 620):

The method that I have found convenient is as follows: 40 c.c. of the urine, filtered, acid reaction, free from albumin and sugar, are boiled with 2 c.c. of strong hydrochloric acid for ten minutes. After partly cooling, 8 gm. of lead carbonate are gradually added. When the reaction is complete, the mixture is chilled, filtered, and 10 c.c. of filtrate diluted to 20 c.c. with distilled water. This solution is precipitated with 2 gm. of tribasic lead acetate, filtered, and the excess of lead in solution removed by the addition of 2 gm. of sodium sulphate, bringing the mixture to a boil, chilling, and filtering to 20 c.c. To this filtrate there is now added a mixture of phenylhydrazin hydrochlorate 0.80 gm., sodium acetate 2 gm., and of fifty per cent glacial acetic acid 1 c.c., and the whole is boiled on a sand bath for ten minutes. The solution is then filtered while hot and set aside to crystallize. The precipitation of crystals, sometimes only in microscopic quantities, of the characteristic formation of ozazones, makes a positive reaction.

The following precautions must be observed:

1. The urine must not contain albumin or sugar, and must be fresh and filtered clear.

2. Positive reactions must be verified by making the phenylhydrazin test for free sugar in the urine, using the same method without previous boiling. Fehling's test is not sufficiently delicate. The sufficiency of removing sugar by previous fermentation has not been proved.

3. Tribasic lead acetate ($Pb(CHO).PbO$) must be employed. The solution of lead acetate of the U. S. Pharmacopeia is not satisfactory. I have employed it side by side with the tribasic lead acetate and have obtained misleading results with the former. Before realizing this difference I had some correspondence with Cammidge on the subject, and I agree with him that the tribasic lead is the only

suitable precipitant, because of the uncertain and indefinite composition of the pharmacopeial preparation. The positive reaction may be marked or may require microscopic examination. I have noted precipitates that were not crystalline, and therefore negative. Precipitation may take place immediately on filtering or may occur after standing twenty-four hours. Except as to size, the crystals that I have observed in various positive reactions were apparently of the same system. I cannot concede any value whatever to such tests as solubility in sulphuric acid, as tending to point to the nature of the disease, and I have therefore never applied this test.

Pancreatic Calculi.—Stones consisting of carbonate and phosphate of lime are occasionally found in the pancreatic duct. They cause symptoms from obstruction and may eventuate in abscess or in chronic pancreatitis. Such stones have been passed *per rectum*, have been found in an abscess of the pancreas, and have been removed from the papilla after incision of the duodenum, and have been removed by incision of the pancreas from the pancreatic duct. The symptoms produced hardly admit of a definite diagnosis before operating. Colicky pain, jaundice, free fat in the stools, and localized tenderness. In general, symptoms corresponding with those of obstruction of the papilla or of chronic pancreatitis, etc.

Solid Tumors of the Pancreas.—A variety of forms of benign tumor have been observed as rare conditions in the pancreas. Among them may be mentioned adenoma, lymphoma, and a few others. Syphilis and tuberculosis of the pancreas may give rise to the formation of a nodular or diffuse swelling of the organ, but none of these conditions possess any great surgical interest. Sarcoma of the pancreas has also been recorded. Much more frequent than any of these is cancer. Carcinoma of the pancreas may occur secondary to cancer of the stomach or duodenum or to cancer of the common bile duct. Under these conditions it will only be of surgical interest incidentally. Primary carcinoma of the pancreas is not at all rare. It is a disease of advanced life. Several forms of cancer have been observed—scirrhus, adenocarcinoma, and other forms. The disease begins in the head of the pancreas more often than elsewhere. The early symptoms are in general so indefinite that a positive diagnosis is scarcely to be made. Late in the disease the diagnosis is usually simple. The symptoms consist briefly of pain in the epigastrium, loss of flesh and strength, a rapid development of cachexia, and later on the formation of a tumor. In addition, there are frequently present symptoms due to pressure upon the common duct. They are not usually developed very early, and if the carcinoma is situated in the body or tail of the pancreas, they may not appear at all. Changes in the urine and in the stools, although they may occur, have no definite diagnostic significance. The patients usually run down very rapidly in health, ascites is not uncommon, and the duration of life is seldom more than a year. The most important diagnostic sign is the formation of a palpable tumor. When the cancer develops in the head of the pancreas and obstructs the common duct, there is usually steadily progressive and

finally very intense jaundice and a distended gall-bladder. The differential diagnosis of cancer and common-duct stone, in which latter condition the gall-bladder is rarely distended, has already been spoken of in another place. There is frequently a history of gall-stone disease. The following brief abstract of the history of a case of cancer of the head of the pancreas will serve to illustrate the condition. The case occurred in my practice in 1905:

Mrs. M., aged fifty-six years, had suffered from attacks of biliary colic at intervals for nine years. During the past six months the attacks have occurred very frequently, and are now associated with a constant sense of oppression and discomfort in the epigastrium. For the past six months she has grown steadily weaker and more anemic. For the past two months there has been a slight but continuous jaundice, which has grown deeper from week to week. The patient vomits occasionally. She has no appetite. Her bowels are constipated. She has had no fever. She is a large, fat and flabby individual, who looks decidedly cachectic. The general integument and the sclera of the eye shows a moderate icterus. Her stools are light in color, although not entirely free from bile. Her urine contains biliary pigment. On palpating the abdomen a distended gall-bladder is readily felt below the free border of the liver. The liver dullness extends three finger breadths below the costal arch. The gall-bladder is tense, but not markedly tender. There is no abdominal rigidity. Diagnosis of probable cancer of the pancreas. Upon opening the abdomen the gall-bladder was found notably enlarged, moderately thickened, and distended with a mucoid fluid. A dozen small biliary calculi were removed from the gall-bladder. Upon palpation two small stones were found in the cystic duct and were removed with a scoop. Bile was then discharged in moderate quantities through the gall-bladder. Upon palpating the pancreas a nodular, hard tumor of the head of the pancreas could be felt. A small portion was removed for microscopic examination. The diagnosis of cancer, however, appeared to be clear from the gross appearance and physical qualities of the growth. The tumor was about the size of a hen's egg. A biliary fistula was created by stitching the gall-bladder to the abdominal wall; the patient's condition being very feeble, it was considered best not to join the gall-bladder to the intestine. The patient recovered from the operation. Bile continued to be discharged in moderate quantities through the fistula. She was able to be up and about after the usual time, and returned to her home in the country, where she died some months later of progressive exhaustion, not having suffered much acute pain at any time.

The treatment of cancer of the pancreas offers but little hope of cure. Robson has recorded fourteen cases where the tumor was removed, with ten deaths. These patients do not bear intra-abdominal operations at all well. No cures are recorded, and most of the attempts at the radical removal of the growth resulted fatally at once.

Cystic Tumors of the Pancreas.—Cystic tumors of the pancreas are by no means rare. Recent literature contains the histories of a pretty large number of cases. Although owing to somewhat imperfect records I cannot be positive, I am under the impression that during the years from 1890 until 1900, while I assisted Dr. Charles McBurney in the Roosevelt Hospital, there were in this

time ten cases of cyst of the pancreas operated upon. Personally I operated upon two in the year 1906.

Lazarus's classification of cystic tumors of the pancreas, according to their origin, is as follows: First, retention cysts of the secretory ducts of the pancreas (Virchow, *Ranula pancreatica*). Second, proliferation cysts, cystadenoma, according to Lazarus, the most frequent form. Third, retention cysts due to obstruction of the smaller ducts of the acini resulting from chronic interstitial pancreatitis (these latter are supposed to be due to injury or to the spread of an inflammatory process from the intestine and bile ducts). Fourth, Lazarus believes that by the softening of a tumor (carcinoma), autodigestion of an encapsulated hematoma which is not absorbed, or by the degeneration of lobules of the gland as the result of acute pancreatitis, cystic tumors of the pancreas may be produced. Fifth, pseudocysts. By this term is meant that an inflammatory exudate or a hematoma in the lesser sac of the peritoneum may produce a hydrops or an empyema of this lesser sac, and thus a cystlike formation closely connected with the pancreas. Such cysts are believed by Körte to have followed aseptic necrosis of the pancreas. Hydatids and congenital cysts of the pancreas have been observed as very rare conditions. While it is probable that many cysts of the pancreas arise as true cystic tumors, yet unquestionably cystic formations originating in the gland itself are preceded by a history of injury to the upper part of the abdomen, and are not infrequently complicated by the signs and symptoms of inflammation. Mayo Robson believes of hemorrhagic cysts that there is no valid or acceptable evidence of their origin in a hemorrhage merely because the pancreatic tissue shows a marked tendency to bleed on slight provocation, and in all the varieties of pancreatic cyst a more or less blood-stained content is common. The contents of pancreatic cysts are thus described by Körte: The contents are an alkaline, albuminous, mucoid fluid having a specific gravity of from 1.010 to 1.020, higher or lower. In some cases it is clear and colorless, in others the admixture of blood gives it a brownish and sometimes almost a black color. The fluid frequently contains pancreatic ferments. Their absence, however, does not exclude a pancreatic origin. In all the cases I have seen, the fistula remaining after the drainage of the cyst has continued to discharge fluid for periods varying from months to years, and the pancreatic nature of the cyst was in every case demonstrated by a more or less marked digestion and irritation of the skin surrounding the fistula.

Cyst of the pancreas may occur at any time of life, but it is most frequent during middle age—between thirty and fifty years. In about one quarter of the cases there is a history of injury to the upper part of the belly. In these cases the development of the cyst may follow immediately upon the injury or during the course of a few weeks. Such a cyst will be found on operation to be a fluid collection in the lesser sac (pseudocysts) of more or less completely disintegrated blood. If the contents contain a diastase ferment—i. e., convert starch into sugar—a pancreatic origin from injury is

probable (Jordan Lloyd). In some cases the development of the cyst is delayed for months or years. Such patients may have suffered from pain in the epigastrium from time to time, or have had no symptoms. In other cases there will be no history of injury, but preceding the formation of the cyst the patient will have suffered from attacks of epigastric pain and digestive disturbances, suggesting an inflammatory origin of the cyst (Körte). The symptoms produced by the cyst itself are usually slow to develop, and are observed only after it has reached a certain size, so that it interferes with the functions of the stomach. There will then be nausea, attacks of vomiting, gastric dyspepsia, palpitation of the heart, occasionally there will be jaundice, rarely interference with the function of the pancreas itself. Some of these patients suffer some disturbance of nutrition after the cyst has reached a considerable size, but not always. I recall three cases, two of my own and one of Dr. McBurney's, in which, though the tumor was quite large, no disturbances of general health and no symptoms other than distress after eating were present. In one of my cases the cyst grew from the tail of the pancreas toward the left and presented beneath the costal border in the left flank. In the other two the cysts were centrally situated. If the cysts are permitted to grow very large, they may cause, like any other tumor occupying an undue share of the abdomen, very serious symptoms indeed—violent vomiting, obstinate constipation, emaciation, prostration, and dyspnea. The diagnosis of cysts of the pancreas is sometimes easy, sometimes difficult. It is to be borne in mind that a slowly growing cystic tumor of the upper part of the abdomen, especially if a little to the left of the middle line, since the cysts usually form in the body and tail of the organ rather than the head, is more likely to be a cyst of the pancreas than anything else. The cysts may develop and approach the front of the belly in several positions. The commonest type is: (1) The cyst grows into the lesser sac and appears between the stomach above and the colon below, having the gastrocolic omentum in front of it. (2) It may push the stomach in front of it and appear above the lesser curvature, having the gastrohepatic omentum in front of it. (3) It may grow in between the layers of the transverse mesocolon, so that the colon rides across its front or lies just above it. In one case (Albert and Payr) the cyst emerged to the right through the foramen of Winslow into the greater sac (Körte). In one case of my own, as related, the tumor grew from the tail of the pancreas and presented precisely like a hydronephrosis in the left flank, fluctuating, flat on percussion, and with the colon in front of it. This tumor exhibited a moderate degree of passive mobility in a vertical plane. These various relations between the cyst, the stomach, the colon, are very important in the diagnosis. They are to be made out by inflation of the stomach and colon respectively. When the cyst presents between colon and stomach, the inflated stomach will, if the cyst be not too large, lie in front of it, the colon below. In group number two the inflated stomach lies below the cyst, the latter being crowded upward more or less beneath the liver, when it may be mistaken for echinococcus cyst of the

liver. When the colon lies in front of the cyst, as in group three, or crosses its upper border, one would be at a loss to distinguish it from a mesenteric cyst (Körte), or any of the other cystic retroperitoneal growths; and, as stated, when they present in the loin, it is scarcely possible to distinguish them from cystic tumors of the kidney by physical examination. In addition to the above characters, the history of the case, as outlined under symptoms, is a history of injury or of attacks of colicky pain associated with tenderness in the epigastrium. The slow growth, the absence of acute pain and tenderness on palpation, the relatively good health, as compared with malignant disease, the physical characters of a tense, fluctuating, rounded, rather immobile tumor, serve for a probable diagnosis. Under no conditions is the introduction of an aspirating needle into the cyst free from risk. The fluid of these cysts is usually irritating, and may be infectious. Moreover, nothing characteristic in the aspirated fluid may appear. It may contain no ferments; and, on the other hand, ascitic fluid may occasionally have the power of digesting cooked starch to some degree. A number of cases of traumatic or spontaneous rupture of pancreatic cysts have been reported with fatal results. An aseptic incision in the abdomen over the tumor, suture of the cyst to the belly wall, and drainage at one or two sittings, is the safest diagnostic and therapeutic measure. Only rarely are these cysts suitable for extirpation. The sinuses after incision and drainage of pancreatic cysts are always slow to close; they may remain open eighteen months or longer. I have watched seven cases, and all closed eventually without any special treatment, except the use of a small drainage-tube and asepsis, after from three to eighteen months. The surrounding skin can be protected by any bland ointment.

CHAPTER VIII

THE RECTUM

GENERAL REMARKS

ANATOMICAL details from Woolsey, "Applied Surgical Anatomy," and from Merkel. Formerly the rectum was described as that portion of the large intestine commencing at the level of the left sacro-iliac joint at the brim of the pelvis and extending to the anus. At present it is customary to include what was formerly regarded as the upper portion of the rectum—namely, from the pelvic brim to the middle of the third sacral vertebra as a part of the colon and to regard the rectum as that portion of the large intestine extending from the middle of the third sacral vertebra to the anus. In other words, that portion of the gut having a mesentery is now included in the colon. Regarded in this way, the rectum forms a canal which is truly straight in one plane at least—that is, while it curves in an anteroposterior direction it has no lateral curve. The rectum for purposes of description may be divided into two parts: an upper or pelvic portion, three inches and a half in length, which follows the curve of the sacrum and coccyx, and the lower or anal portion, about an inch and a half in length, which bends sharply backward and downward just below the tip of the coccyx. In introducing rigid instruments into the rectum it is important to remember the direction of these two portions, so that undue violence may not be exerted upon the wall of the canal. The axis of the anal portion of the rectum is directed toward the apex of the prostate or toward the rectovaginal septum in the case of the female. In introducing an instrument into the rectum, therefore, it should be introduced upward and forward for an inch and a half, and then rotated backward into the hollow of the sacrum, so that at first it passes upward and forward, and subsequently upward and backward. The dividing line between these two portions of rectum corresponds to the point where the rectum pierces the pelvic floor. The lower or anal portion, therefore, lies entirely without the pelvis and the same is true of the lower part of the upper portion, which lies below the reflection of the pelvic fascia. In children the rectum is much straighter than in adults, and for that and other reasons prolapse of the rectum is more common from comparatively slight causes—i. e., great straining at stool, etc. than is the case with adults.

The Pelvic Portion of the Rectum.—Above the anal portion of the rectum there is a dilated pouch, known as the ampulla, lying between the apex of the

prostate and coccyx. This portion of the rectum is capable of great distention, and is the seat of large fecal accumulations in certain cases of chronic constipation with atony of the gut seen chiefly in old people, as will be described. Distention of this portion of the rectum in the male pushes the bladder upward and forward and elevates the rectovesical fold of peritoneum. The attachments of the rectum to the surrounding structures are relatively loose, so that the rectum is really a very mobile portion of the gut. In order to completely free the rectum, so that it may be pulled down in certain operations, the fibers of the levator ani muscle must be divided and the peritoneal attachments loosened. This may be accomplished for the most part by blunt dissection with the fingers. In front the rectum is somewhat firmly attached to the prostate and bladder, but these attachments may be loosened with the fingers quite readily, in operations upon the prostate and seminal vesicles, for example, or upon the rectum itself. In the female the rectum is attached to the posterior wall of the vagina by loose connective tissue. The relations of the rectum are very important from a diagnostic as well as from a therapeutic point of view, since by rectal examination we are able to, as will be described, palpate with comparative ease a good many structures and to acquire valuable information not obtainable in any other way.

Relations to the Peritoneum.—The anatomical details are adapted from Woolsey, "Applied Surgical Anatomy." Commencing opposite the third sacral vertebra the peritoneum alone represents the mesorectum. It covers at first the front and sides of the bowel, and is reflected from the latter along an oblique line descending from behind forward. It is finally reflected from the front of the rectum on to the bladder in the male and on to the vagina, cervix, and uterus in the female, forming the rectovesical and rectovaginal pouch (Douglas's pouch) respectively. The distance of the rectovesical peritoneal pouch from the anus is of importance; it measures about three inches when the bladder is empty and as much as four when it is full. The distance of the rectovaginal pouch from the anus in the female is somewhat less than in the male. It is important to bear in mind that a complete prolapse of the rectum of considerable size carries with it this pouch of peritoneum, and intestinal coils may also be contained in such a prolapse. On the posterior wall of the rectum the peritoneum reaches downward to a point about five inches or more from the anus. Thus cancers of the rectum situated on its anterior wall are more apt to invade the peritoneal cavity than those situated on the posterior wall. As has already been pointed out in the diagnosis of abdominal diseases, an examination of the rectum is highly important under a great variety of conditions. By rectal palpation in the female we can readily feel the position of the uterus, if retroverted especially, or a prolapsed ovary, and by bimanual palpation the rectum serves as well as the vagina for mapping out the position of the pelvic organs, whether healthy or diseased. In the male we can feel the base of the bladder which is applied to the rectum over a triangular area, the size, conformation, and consistence of the prostate,

and in conditions of disease, when enlarged by ordinary inflammation or tuberculosis, we can feel on either side above the prostate the seminal vesicles; if enlarged and hardened from tuberculosis, we may also be able to feel the vas deferens on either side. It is also frequently possible to feel a stone impacted near the lower end of the ureter, and occasionally I have felt through the rectum a large stone in the bladder. In cases of difficult catheterization the finger in the rectum enables us to feel the tip of a sound or catheter in the membranous urethra, and is sometimes of great assistance in the passage of an instrument in cases of stricture or of enlargement of the prostate gland, and the same may be true in operations upon the perineal urethra (external urethrotomy). By rectal palpation the bony walls of the pelvis may be examined for deformity, fracture, or disease. Posteriorly the front of the coccyx and sacrum may be examined, laterally the spines of the ischia as well as the tuberosities and the bodies of these bones. We may also examine the sacrosciatic foramina, and in front we can examine the posterior surface of the pubic bones, the pubic symphysis, and the obturator foramina. By invaginating the pelvic floor, we can, under an anesthetic, reach with the tip of the finger the sacral promontory. Sometimes it is of advantage, when attempting a high digital examination of the rectum, to examine the patient in the erect position and tell him to strain downward. *The lower or anal portion* of the rectum is an inch and a half in length. It is the narrowest part of the large intestine; but since its narrow caliber is due largely to muscular contraction, it is readily dilated. Formerly it was the occasional practice of surgeons after dilating the anus to introduce the entire hand into the rectum for the purpose of palpation. While this was possible, it is no longer practiced, since serious injury to and even rupture of the rectum have been produced in this way. The anal portion of the rectum is surrounded by the internal sphincter, and to its sides are attached the levator ani muscle, together with its inclosing layers of fascia. In the female the perineal body lies in front, separating the gut from the lower end of the vagina, and the perineum in the male, separating it from the urethra.

Structure of the Rectum.—The longitudinal muscular fibers of the rectum although somewhat more abundant in front and behind, are more uniformly distributed here than in the upper portion of the large intestine. The circular fibers become much more abundant in the upper inch of the anal portion; they form the internal sphincter. The lower limit of the anal portion is represented on its interior by a circular white line which marks the junction of the skin and mucous membrane. The external sphincter surrounding the anal orifice is a striped or voluntary muscle. The submucous tissue of the rectum has so loose an attachment to the mucous membrane of the bowel that, especially in children, irritation of the rectum, such as is caused by the presence of worms and polypi, producing straining at stool, makes prolapse of the rectum quite common in early life. When present only to a slight degree, the prolapse may involve the mucous membrane merely, but in well-marked cases all the

structures of the rectal wall may be included in the prolapse and the peritoneal pouch as well.

Houston's Folds or Valves.—Certain obliquely transverse folds of mucous membrane exist in the rectum which are not effaced by distention of the bowel. These may catch the point of a bougie or other instrument introduced into the rectum and impede its progress. An overdevelopment of these valves is believed by certain practitioners to be a cause of constipation. Whether this contention rests upon any basis of fact I know not. There are usually three such folds: One, the largest, on the right and anterior aspect of the gut, is near the rectovesical pouch of peritoneum, or about three inches from the anus, and projects from half an inch to three fifths of an inch into the gut, extending around one half of its circumference. It is sometimes described as the third or upper sphincter. The other two folds are on the left above and below the former, and the three are so arranged as to form a kind of spiral valve. They may be more or less distinctly seen when examining a patient in the genupectoral position when a tubular speculum is introduced into the anus, so that the bowel becomes distended with air. In the anal portion of the rectum, commencing just above the orifice, are from three to eight longitudinal columns or folds of mucous membrane from a third to half an inch long. Between the lower ends of these columns are semilunar folds or valves whose upturned concavities form little sinuses. These are known as the columns, valves, and sinuses of Morgagni.

The epithelium lining the rectum is of three different types: In the lowest zone as far up as the lower border of the internal sphincter the epithelium is of the ordinary cutaneous type, flat squamous epithelium. Above the white line is the so-called intermediate zone, about half an inch broad, covered with flat epithelium, but not of the horny type. Above this point the epithelium is of the columnar variety, and, as will be noted when speaking of the tumors of the rectum, the cancers originating in the anal portion are of the flat, squamous, epithelial-celled type, whereas cancers beginning in the mucous membrane of the rectum proper are usually of the type of adenocarcinoma—that is, the cells are columnar.

Blood Supply of the Rectum.—The *arteries* of the rectum are derived from three principal sources: The inferior mesenteric, the internal iliac, and the internal pudic. The superior hemorrhoidal vessels on either side pierce the muscular wall of the rectum about three inches from the anus and form a longitudinal network in the submucous tissues. Hence, transverse incisions in the wall of the rectum are to be avoided, since they bleed profusely. The arteries communicate very freely in a plexiform network near the anus. The *veins* have much the same plexiform arrangement in the submucous tissue of the lower rectum, but most of the blood is returned by the superior hemorrhoidal to the inferior mesenteric vein. Hence anything which interferes with the portal circulation, such as the pressure of tumors, cirrhosis of the liver, etc., will cause congestion of the hemorrhoidal veins, such as also occurs from a general interference with the venous circulation from heart disease, diseases

of the lungs, etc. (See Hemorrhoids.) The inferior hemorrhoidal veins empty into the caval system, and thus a free anastomosis exists here between the portal and caval circulation.

Nerve Supply of the Rectum.—The nerve supply of the rectum is from the inferior mesenteric and hypogastric sympathetic plexuses and the sacral plexus (fourth sacral nerve). The latter nerve supply accounts for the paralysis of the sphincter, with incontinence of feces that follows spinal injuries or diseases in the lumbar region of the cord, or above, and is largely responsible for the close nervous connection between the anus and the outlet of the bladder which is supplied by the same nerve, so that retention of urine frequently follows operations upon the rectum, and inflammatory or other diseases of the bladder are often accompanied by rectal tenesmus. The skin of the margin of the anus is exquisitely sensitive to painful impressions, so that it is wise to administer a general anesthetic for all but very small operations in this locality. The anal margin is supplied by the internal pudic nerve. Above this point the rectal wall is ordinarily sensitive for a distance of two inches. The deeper portion of the rectum, on the other hand, is far less sensitive. It is, however, well to bear in mind that just behind the cervix there is a more tender area, pressure upon which in rectal or vaginal examinations will cause pain, though no pathological condition be present. The lymphatics of the rectum enter the pelvic and lumbar lymph nodes, those of the anus the inguinal lymph nodes. Hence, *cancer* and inflammatory processes of the *anus* cause infection and enlargement of the *inguinal glands*. Similar processes of the *rectum* proper infect the *pelvic glands*.

The Anus.—The *anus* is an oval orifice with a long anteroposterior diameter; therefore flattened instruments should be passed through the anus with this fact in view. The anus is in the middle line, an inch and a half in front of the coccyx, equidistant from the ischial tuberosities. In health the external sphincter is in a state of tonic contraction and keeps the skin of the anus under normal conditions puckered into radiating folds. Painful fissure of the anus forms in the sulci between these folds, and in order to see these shallow cracks or ulcers it is sometimes necessary to spread the anal orifice a little with the fingers. Secondary syphilitic mucous plaques, on the other hand, form along the tops of the cutaneous ridges, and may be differentiated from simple ulcer or fissure at a glance. In painful fissure the sphincter is in a condition of spasm from reflex irritation. Certain conditions cause the external sphincter to become relaxed and flabby, the ridges and furrows disappear, and the skin of the anus is smooth. One sees this in very old and feeble persons, after injuries of the spinal cord, in obstruction of the upper portion of the rectum from tumors or strictures, and during the later stages of labor when the head begins to press upon the perineum. The habitual practice of passive pederasty is said to produce permanent relaxation of the anal sphincter and a peculiar funnel-shaped appearance of the anus—the so-called "infundibuliform anus." This appearance is of possible diagnostic importance.

METHODS OF EXAMINING THE ANUS AND RECTUM

The examination of the rectum begins properly with the inspection of the nal orifice. For a simple examination, including merely digital exploraion of the rectum, the patient, if a male, may be asked to bend his body far orward over the back of a chair. If the patient is a woman, or if a thorough xamination is necessary, Sims's position, or the knee-elbow position, should e used. The dorsal position is useful for palpating the rectum, but unless he pelvis is raised higher than the head, it is not as good for examining the ectum with a speculum as the knee-chest or Sims's position. It is, however, seful in a considerable proportion of the operations upon the rectum. After nspecting the anal orifice, the folds of skin should be obliterated by separatng the margins of the anus a little with the fingers. In palpating the interior f the rectum, it is desirable that the surgeon should wear upon his forefinger thin rubber finger cot. If such is not obtainable, a rubber glove may be worn, r in default of this, the space beneath the finger nail may be filled with soap. The finger should be well lubricated with vaselin or some other lubricant and ntroduced gently. The various normal structures to be palpated have already een mentioned; in addition, the existence of strictures, of tumors, of ulcerated surfaces, and cicatrices can be readily detected. It is not easy to feel internal hemorrhoids; they are soft tumors, and frequently produce no palpable mass. By stretching the anal orifice a little and asking the patient to bear down, they may often be made to protrude through the anus. In females one finger may be introduced into the vagina, and the anterior wall of the rectum may be everted by the pressure of the finger. As already noted, if one wishes to palpate the rectum very deeply, it is sometimes of advantage to examine the patient in the erect posture.

For purposes of inspection we may use one or other form of speculum. The bowel should have been previously emptied by purgatives or enemata. The knee-chest position is in every way the most desirable for this examination. The patient should be close to the edge of the table, the thighs should be vertical, the back depressed, and the chest as close as possible to the table. There should be no constricting garments about the waist. One may use an ordinary tubular speculum of glass or of hard rubber with an obturator, or, better, one of Kelly's instruments. The set of specula necessary for all purposes include four: A short and a long proctoscope, a sigmoidoscope, and a sphincteroscope. The cylinder of the short proctoscope is 5½ inches long and 22 mm. in diameter; the long proctoscope is 8 inches in length and 22 mm. in diameter. The sigmoidoscope is 14 inches in length and 22 mm. in diameter (Kelly). The cylindrical tube has a funnel-shaped rim at its upper end, to which is attached a stout handle large enough to be grasped in the entire hand. Each speculum should have a suitable obturator, blunt on the end. The sphincteroscope is short and slightly conical. Its diameter at the lower end is 1 inch and at the upper end 1½ inches. It also has an external flange and a strong handle.

The instruments are introduced in the following way: After lubrication with vaselin the round end of the obturator is placed against the anus and the speculum is grasped, so that the obturator is continually pushed forward. As already noted, it should be introduced first in a direction upward and forward, and then turned upward and backward toward the hollow of the sacrum. If

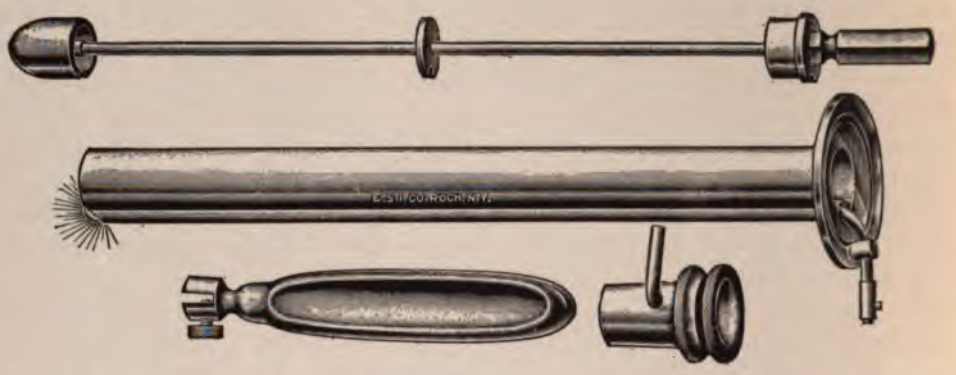


FIG. 31.—SIGMOIDOSCOPE WITH ELECTRIC LIGHT AT ITS DISTAL END TOGETHER WITH THE ATTACHMENT FOR CLOSING THE PROXIMAL END OF THE INSTRUMENT AND INFLATING THE BOWEL. Useful in examining the upper part of the rectum and the lower part of the sigmoid.

the instrument catches in a fold of mucous membrane, it may be withdrawn a little, and then gently pushed onward. When fully introduced the obturator is removed, and, on account of the position in which the patient is, air rushes in and distends the bowel.

For purposes of illumination one may use an ordinary head mirror and a suitable light; best an electric light or bright daylight, or, as I prefer, an electric headlight. The mucous membrane of the bowel can then be inspected very perfectly. By moving the instrument from side to side the entire surface of the gut can be brought into view. The normal color of the gut is pale red, not deep red. When the instrument is a short one, Houston's valves, as already described, are visible. The promontory of the sacrum creates an elevation in the wall of the gut, and its nature is readily identified by touching it with the end of the instrument. For examining the sigmoid flexure it is necessary to use the longer instrument or sigmoidoscope. Specula are now in general use furnished with a minute electric light near the distal end of the tube, as well as an attachment for inflating the bowel, if desired. I have used them (Tuttle's rectal specula) with much satisfaction. It will be noticed that as the instrument gets to the upper portion of the rectum, it assumes a direction a little toward the left. By the use of gentleness the instrument may be introduced quite readily and without undue discomfort to the patient. As the specula are gradually withdrawn the lower portions of the rectum successfully come into view, and any abnormalities present may be studied—spots of congestion, ulcerations, polypi, fistulous orifices, etc. For

purposes of inspection bivalve and trivalve instruments are far less useful, and anyone who has once accustomed himself to the use of a tubular rectal speculum in the knee-chest position will scarcely care for any other method of examination. In operations upon the rectum one frequently uses a Sims's speculum or some modification of it. Two such specula are sometimes useful. They are not, however, very useful for mere diagnostic purposes, since they cause pain and require a general anesthetic, and do not give so good a view as the tubular speculum. A certain number of pathological conditions in the rectum will require dilatation of the sphincter muscle for proper diagnosis. This is accomplished under a general anesthetic; the bowel having been previously emptied and cleaned, the surgeon introduces at first two and then three well-lubricated fingers into the anus with a boring motion, and continues slowly to advance the fingers until the sphincter muscle is felt to be entirely relaxed, soft, and pulpy. The muscle may also be stretched by introducing first one and then the other thumb and gradually stretching the anus, being careful not to use sudden force, until the resistance of the sphincter is entirely overcome.

CONGENITAL ABNORMALITIES AND DEFECTS OF THE RECTUM AND ANUS

The embryology of the lower gut is interesting from a pathological point of view, because errors in its development give rise to congenital defects of great consequence surgically. Want of space forbids more than very brief mention of the formation of the several types of congenital defect of this portion of the intestine. Suffice it to say that the pelvic portion of the rectum is formed from the blind caudal end of the hind gut; the anal portion by the development of a depression of the skin surface at the site of the anus. Normally the tissue between the pelvic and cutaneous parts respectively undergoes absorption, so that a continuous canal is formed. If this absorption fails to take place, the passages do not communicate, and the condition is then known as imperforate anus. In these cases the septum may be thin and membranous, so that the dark color of the meconium shimmers through, or much thicker, half an inch or more. The entire anal portion may be absent or closed, so that the pelvic portion of the rectum comes to an end at a greater or less depth from the surface. When simply a thin membrane exists between the pelvic and anal portions of the gut, the condition is known as external anal atresia; when the anal portion is entirely wanting, the condition is known as total anal atresia. In other cases there is a defect not only of the anal part, but also of the rectum proper, so that the rectum may end in a blind pouch, at a variable distance from the perineum. In some cases the rectum will come down as far as the prostate, in others it may end in an intraperitoneal sac opposite the last lumbar vertebra or the brim of the pelvis. This condition is known as atresia of the anus and rectum. Another type of the deformity is known as

atresia of the rectum. In this the anal portion is properly developed, but the pelvic portion fails to unite with it, the child possesses a normal anus, ending above in a blind sac. There may be only a membranous diaphragm separating the two portions, or a considerable mass of tissue; sometimes the two parts are united by a fibrous cord; sometimes a narrow channel may be present of considerable length, constituting a congenital tubular stricture of the rectum. In other cases a thin diaphragm only intervenes between the anal and rectal portions, perforated by an orifice of small size, constituting a congenital linear or membranous stricture. In a small proportion of cases a fistulous communication exists between the rectum above and the outside of the body, either directly through the skin, or through the base of the bladder, the prostatic urethra, or through the wall of the vagina above the hymen, or into the uterus of females, or just below the hymen in the perineum. These external fistulous openings with the exception of the last are usually quite narrow; for the most part too narrow for the proper evacuation of the bowels. The last form, however, is usually of considerable size, and women have grown up and borne children with this condition, not having suffered any especial discomfort from the deformity. The external fistulæ in boys may open in the middle line of the perineum just behind the scrotum, or through the scrotum, or through the middle line of the under surface of the penis as far forward as the frenum.

The *symptoms* produced by these various forms of atresia depend upon whether the obstruction is absolute or whether fistulæ exist, their size, and where they open. When the obstruction is complete, the infants do not survive many days if unrelieved by operation; rarely longer than a week. As soon as they begin to swallow food, bacterial fermentation begins in the intestine, the abdomen swells, the child vomits at first food and mucus, later meconium, pressure of the distended bowel upon the diaphragm causes dyspnea and cyanosis; they pass into a condition of collapse and perish. In some cases the distended gut has burst and produced death from peritonitis. When a fistula exists, the duration of life varies. If the orifice be very small, the symptoms of intestinal obstruction will develop as before, and death will ensue. If larger, but yet not large enough, chronic intestinal obstruction, a dilated colon, and intercurrent attacks of acute obstruction may occur; the child may linger miserably for months. If the fistula be internal and empty into the bladder or prostatic urethra, meconium and feces will be passed at *each urination*, and the urine will be uniformly brown in color. Severe cystitis and pyelonephritis will destroy life in these cases. If the fistula open into the membranous urethra or bulbous portion, meconium will escape from the urethra independent of urination; the urine may at times be clear. If the fistula open on the integument, it may be very small and hard to find, unless meconium be seen escaping from it. When it opens into the vagina meconium will appear at the vulva. In most of the cases the diagnosis will not be difficult. The fact that a baby has no movement of the bowels after a reasonable interval will lead to an examination of the anal region. If there be no anal opening,

the fact is apparent at once. If an anus be present, the finger should be introduced to feel if there be obstruction above, and its character. If such be found, immediate operative treatment should be instituted, and the simpler the operation the better. If access is not speedily gained to the pelvic portion of the rectum, iliac colostomy of the sigmoid is to be made. In the cases where some opening exists the surgeon must be guided by the conditions. If the opening, wherever situated, be adequate, unless it be into the bladder, no operation, or at least no extensive operation, should be done at the time. The child should be allowed time to gain strength and vigor. This is notably true of the cases where the outlet is at the fourchette below the hymen; they are usually adequate in size, and may be operated on to better advantage later in life. When the opening is into the bladder, operation offers the only chance of preserving life.

FOREIGN BODIES IN THE RECTUM

Foreign bodies in great variety may be found in the rectum. They may gain entrance through the mouth by being swallowed intentionally or accidentally, or be introduced from below through the anal orifice, as the result of accident or design. Furthermore, there occur in the rectum accumulations of fecal matter, and sometimes actual enteroliths find lodgment in the rectum as a rare surgical condition. As has already been described in speaking of foreign bodies in the alimentary canal in general, the majority of those which successfully pass the pylorus and ileo-cecal valve also succeed in passing the anal orifice without much difficulty. It occasionally happens, however, that large, or angular, or pointed foreign bodies swallowed by accident or design are caught in the rectum and become impacted; or if they be very small find lodgment in one of the pockets of the mucous membrane—as, for example, in the sinuses of Morgagni. Large and irregularly shaped foreign bodies, such as knives, forks, spoons, and indiscriminate metal articles of various kinds, may be swallowed by lunatics, by children, rarely by hysterical individuals, and by professional swallowers of foreign bodies. Among the commonest types of foreign bodies swallowed unknowingly or by accident are fish bones and the bones of small birds, chickens, or of small game of one sort and another. The behavior of foreign bodies lodged in the rectum varies greatly. If they are neither angular nor sharp nor very large they remain in the ampulla of the rectum for an indefinite time without causing symptoms. If they are sharp or jagged or large they may cause symptoms by pressure or by obstruction of the bowel. By pressure they may set up ulceration and perforation of the wall of the gut with the formation of a phlegmonous abscess in the perirectal tissues, or cause a severe proctitis with the passage of blood and mucus in the stools, accompanied by severe pain and tenesmus. Occasionally they may ulcerate into and perforate neighboring organs and cavities, the bladder, the vagina, the peritoneal cavity, or the ischiorectal fossa. One finds not very rarely

when operating upon an ischiorectal abscess that the cause of the infection has been the presence of some small body in the rectum which has caused pressure necrosis and ulceration—a bit of fish bone, for example—and such a body is occasionally discovered when the abscess is incised. Enteroliths, although comparatively very rare, occasionally lodge in the rectum, and may either give rise to no symptoms, to a catarrhal inflammation, to pressure necrosis of the mucous membrane, or by gradual accretion they may attain such a size as to produce more or less marked symptoms of obstruction. In those who habitually take morphine, in old and feeble persons who suffer from chronic constipation, among certain paralytics, and among neglected cases of injury of the spinal cord with paralysis, it not infrequently happens that collections of fecal matter form in the ampulla of the rectum. As has already been described, such accumulations may reach an enormous size. They may be as large as a fist, as large as a child's head at term, or may even completely fill the pelvis. The symptoms produced are due to pressure upon the surrounding viscera, the bladder, etc., to intoxication from the absorption of decomposition products, to obstruction of the bowel, sometimes associated with diarrhea. Foreign bodies gaining access to the rectum from below may do so by accident or by design. By accident they may enter the rectum through the anal orifice or first perforate through the perineum or through the ischiorectal fossa, and subsequently perforate the wall of the gut. Such accidents occur when an individual falls from a height in a sitting posture upon a stake, upon the projecting stub of a branch of a tree lying upon the ground, or upon any more or less sharp object—a bottle, for example, etc. The injuries produced are of a varied character, and will be spoken of under Injuries of the Rectum. Foreign bodies may be introduced through the anus into the rectum by design under a variety of conditions. Such may be rarely by criminal intent or with the idea of gratifying a perverse sexual feeling either by the individual himself or by another; occasionally among hysterical and insane persons for reasons best known to themselves, and sometimes with the intention of relieving constipation. Thus, Dr. Stewart exhibited a lead pencil a few years ago at a meeting of the New York Surgical Society which he had removed from the cecum of a man who came to the hospital suffering with what was believed to be an attack of appendicitis. Careful inquiry elicited the history that this man had been constipated some two years before, and had introduced a lead pencil nearly six inches in length and sharpened at one end into his bowel for the relief of constipation. The blunt end of the pencil was introduced first. The pencil slipped out of his fingers and was lost. Some time thereafter he began to suffer from pain and tenderness in the right iliac fossa. Upon opening the abdomen the pencil was felt lying within the cecum, and was removed through the stump of the amputated appendix. The case is a rare one, and illustrates the fact that a long and pointed object with the point downward may find its way, in the large gut, at least, in a direction opposite to that of peristalsis. As may be noted from the foregoing, the symptoms produced by

foreign bodies in the rectum will vary greatly under different conditions. The diagnosis is, of course, in most cases entirely simple, and is made by a digital examination, and, if necessary, an ocular inspection of the cavity of the rectum. The wise surgeon will never omit making a digital examination in cases suffering from symptoms of irritation, or inflammation, or obstruction of the rectum. When a foreign body is present, it will usually be readily discoverable. This caution is especially important in the cases of old and feeble persons suffering from constipation or diarrhea. If the surgeon is unwise enough to omit a digital and ocular examination of the rectum, he may, and probably will, commit grievous errors in diagnosis. This will be especially true when individuals have introduced foreign bodies into the rectum for reasons best known to themselves, and are ashamed to acknowledge the fact, or in cases where foreign bodies have been swallowed and the individual is unaware of their presence. Thus, a man entered the hospital with the symptoms of purulent peritonitis and died. At the autopsy a long hat pin was found in his sigmoid. The upper end of the pin was blunt and rounded, the lower end had penetrated the gut opposite the brim of the pelvis, and caused the fatal peritonitis. The pin was firmly impacted in the bowel. It was learned that the pin had been introduced into the bowel by another individual during the time when the victim of the fatal joke was in a drunken stupor.

These bodies impacted in the sigmoid are quite apt, in the absence of a suitable history, to escape notice.

INJURIES OF THE RECTUM

The rectum, as is the case with other regions, may be injured by incised, stab, contused and lacerated, and gunshot wounds. Among the causes of lacerated wounds of the rectum is the accidental wounding of the canal by the nozzle of a syringe used for the purpose of administering an enema. It has happened in a number of instances that the bowel has been wounded and even perforated by such a nozzle. The wound is usually in the anterior wall of the rectum. But I recall a case which happened many years ago in one of the large hospitals in this city where a long, rather pointed hard-rubber instrument introduced into the rectum for the purpose of giving an enema was passed through the rectal wall posteriorly into the peritoneal cavity; the enema was administered, and the patient died of general peritonitis. If the extraperitoneal tissues surrounding the rectum had been penetrated, the result would probably have been a phlegmonous inflammation. As noted under foreign bodies, lacerated wounds of the rectum occasionally occur from falls upon sharp objects, and the object may enter the anal orifice, and thus wound the rectum, or through the perineum. Such accidents happen chiefly from falls upon the buttocks upon a stake, or the like, or when an individual is gored by a bull. The injuries produced are, of course, of a very varied description and

of a very variable degree of severity. When an individual falls from a height upon a long sharp stake, or the like, which penetrates the rectum or the perineum for a greater or less distance, the injury is known as impalement. In certain semicivilized countries impalement is, I believe, still used as a means of executing criminals or other objectionable persons. The injuries produced by impalement are of a varied and frequently of a fatal description. If the penetrating instrument enters the bowel, and is of considerable length, it will penetrate the wall of the gut and produce severe and usually fatal injuries of the surrounding structures—the bladder, the uterus, the vagina, the intestine, the stomach, the liver, the diaphragm, etc. Typical cases of impalement, however, are described in which the rectum itself remains uninjured. If, for example, an individual falls from a height upon a sharp stake, the wound of entrance is frequently in the perineum in front of the anus. The stake is apt to pass not into the pelvic cavity, but subcutaneously in front of the symphysis pubis; it then travels a variable distance subcutaneously or along beneath the sheath of the rectus muscle, and only enters the peritoneal cavity in the epigastrium, whence it may wound the diaphragm, the lung, the mediastinum, etc. Wounds of the vagina involving the rectum are common during labor. The pressure of the fetal head may cause pressure necrosis, opening finally into the rectum, or the vagina and anterior wall of the rectum may be torn to a variable extent as the head emerges through the vulva. Wounds of the vagina and rectum, often of a fatal character, may occur as the result of the rape of infants. During the years I served in the Roosevelt Hospital out-patient department, I saw several lacerated wounds of the rectum produced by criminal assault upon little boys. In two or more cases the children had at the same time been infected with syphilis. Incised wounds of the rectum are caused more often by surgical operations than by other means.

Gunshot Wounds of the Rectum.—Cases are recorded—among them that of a distinguished Union general during the Civil War in America—of gunshot wounds of the rectum in which the bullet has entered the anus and traveled upward, producing a fatal result without any evident external wound. In gunshot wounds of the rectum in which the bullet passes through the body from before backward, the bladder and the peritoneum have usually been injured. When the bullet has passed from side to side injuries of the pelvic bones and the nerve trunks are often associated.

Symptoms.—The symptoms of wounds of the rectum are chiefly those of bleeding, and later of infection. The rectum is very richly supplied with vessels, and a very small wound is capable of producing dangerous and even fatal hemorrhage. So long as the sphincter muscle remains intact there may be no external sign that bleeding is going on, and the same may be true after operations upon the rectum when the anus is plugged with gauze. The blood accumulates in the ampulla, finds its way upward into the sigmoid and even beyond, and serious or even fatal bleeding may occur without any external sign. The general symptoms of hemorrhage will be present; the

patient will suffer from restlessness and thirst; the skin surface and mucous membrane will become pale; respiration hurried and sighing; the pulse rapid, feeble, and compressible; fainting may occur, in addition to which there will usually be an increasing severe abdominal pain and rectal tenesmus. I saw such a case many years ago following a very simple operation for hemorrhoids done by a distinguished surgeon in this city; it made a profound impression upon me at the time, which I have never forgotten and which has led me to pay very careful attention to the permanent control of all bleeding when operating upon the rectum. I was called to see the patient eight or nine hours after the operation, and found him tossing about the bed in great pain and with all the symptoms of severe hemorrhage. Upon removing the packing from the bowel a very large quantity of blood was evacuated. The bowel was washed out with hot water, and, having no instruments with me, I was obliged to control the bleeding by making a very large, hard, spherical tampon out of strips of toweling; to this was attached two heavy pieces of window cord; this was introduced into the rectum—the sphincter having been, of course, previously dilated at the time of the operation—and these were tied, with firm traction, over another large, hard, cylindrical pad placed on the perineum. The counter pressure of these pads stopped the bleeding. The patient survived.

Although injuries of the rectum are rapidly repaired on account of its abundant blood supply, yet these wounds are constantly exposed to intestinal contents, and therefore to infection. If the wound is produced by the entrance of a foreign body, intestinal contents may be driven into the tissues at the time of the injury. If the rectum was empty at the time of the wounding, it will, nevertheless, be exposed to infection subsequently, and this is especially true of wounds above the insertion of the levator ani muscle. In wounds below this point the conditions are more favorable for healing. If the wound penetrates the rectum above the levator ani, septic inflammation of the loose perirectal fatty and connective tissues is very prone to develop behind the peritoneum, and usually with a fatal result. If the peritoneum is penetrated septic peritonitis will follow the escape of the contents of the bowel into the peritoneal cavity. If the rectum and the bladder are simultaneously wounded a putrid cystitis is likely to follow.

INFLAMMATIONS OF THE RECTUM AND SURROUNDING STRUCTURES

Intertrigo.—As the result of prolonged exercise, such as walking, there occurs, notably in fat persons and in those who are not cleanly in their habits, an acute inflammation of the skin between the buttocks in the vicinity of the anus. The symptoms produced are a sense of heat, burning pain, and itching. Upon inspection the opposed skin surfaces on either side are found intensely reddened, frequently moist and excoriated. The diagnosis is usually entirely simple.

Furuncles.—Furuncles, large and small, not infrequently occur near the margin of the anus. They are intensely painful; their diagnosis is to be made upon inspection without difficulty. (See Furuncle.)

Pruritus Ani.—An affection which tends to become chronic, the causes of which are often entirely obscure and which may render the life of an otherwise healthy person quite miserable, is known as pruritus ani—itching of the anus. The condition has been ascribed to a great variety of causes—to constipation, to a sedentary mode of life, to want of exercise, to articles of diet, to gout, to the presence of oxyuris vermicularis, notably in children. Oftener than not, I have seen the disease in individuals otherwise quite healthy, who were careful of their diet, were cleanly, and led an entirely normal life.

The *symptoms* are an intolerable itching of the skin in the vicinity of the anus. Frequently these patients are entirely comfortable during the daytime; the itching only begins when they are warm in bed at night. The sufferer is irresistibly impelled to scratch. Sleep is seriously interfered with, and if the patient falls asleep, he wakes himself up by scratching. During the earlier stages of the disease inspection may show no visible changes in the skin; after the condition has lasted for some time, the skin between the buttocks over a semicircular area, upon either side, becomes thickened, furrowed, sometimes fissured, of a pearly white color, sometimes with papillary outgrowths here and there upon its surface. The local appearances and the characteristic symptoms suffice for the diagnosis. Search should be made for local and general causes. These patients are often congenitally neurotic individuals.

Acute and Chronic Inflammation of the Rectum—Proctitis.—Acute catarrhal inflammation of the rectum may be caused by mechanical or chemical irritation—as, for example, from the presence of foreign bodies, the use of irritating substances for injection into the rectum, the use of irritating purgatives, and it is supposed also from exposure to cold and wet, rheumatism, and other constitutional conditions. As described under Foreign Bodies and Wounds of the Rectum, injury of the wall of the canal may produce a catarrhal inflammation. The rectum may also become inflamed as a part of a catarrhal or dysenteric inflammation of the large intestine. The condition is frequently observed as a complication of the most varied diseases of the rectum and of the neighboring organs, hemorrhoids, inflammations of the prostate, the seminal vesicles, as the result of the rupture of abscess, in either the male or the female into the rectum—as, for example, abscess of the prostate, ovarian abscess, pus tubes, occasionally from perforation of the rectum by an abscess originating in the vermiform appendix. The *chronic* form of the disease frequently remains after the acute condition has subsided. In the chronic form the mucous membrane may be thickened or be covered with papillary excrescences or polypi. In some cases the disease is complicated by the formation of ulcers of greater or less extent, and such ulceration may lead to infection of the perirectal structures. In the *acute* form the disease is for the most part confined to that dilated portion of the rectum known as the ampulla. In the chronic form the

destruction of the mucous membrane caused by ulceration and the subsequent healing of the ulcers may lead by cicatricial contraction to stricture of the rectum.

The symptoms of acute catarrhal inflammation of the rectum are a sense of heat and burning referred to the rectum itself or to the region of the sacrum, sometimes accompanied by fever and prostration. The pain frequently radiates into the surrounding parts, the thighs, the bladder, etc. The patient suffers from continuous or frequently repeated painful attacks of rectal tenesmus, and during such attacks the attempt to evacuate the bowel is followed by the escape of a small quantity of mucus or pus, sometimes mixed with blood. Frequently the straining efforts cause the mucous membrane of the rectum to protrude through the everted anus. In males there is often frequent and painful urination, sometimes retention of urine. In the chronic stage the symptoms are less intense, the patient suffers from constipation, sometimes from diarrhea, and the stools contain a certain quantity of thick mucus mixed with pus. Frequently the patient is obliged upon rising in the morning to have a movement of the bowels immediately, and such movement consists chiefly of the mucus and pus which have accumulated during the night. The discharge usually causes a chronic irritation of the skin, an eczema and pruritus in the vicinity of the anus. Upon inspection the thickened, roughened, and sometimes ulcerated mucous membrane renders the diagnosis simple, when taken together with the history. Such individuals frequently have a relaxed sphincter. I have seen cases of this kind in which the life of the individual was rendered very wretched indeed. The first two inches and a half of the lower bowel showed irregularly rounded, rather superficial ulcers, sometimes to the number of six, eight, or twelve, with bases covered by grayish flabby granulations and more or less indurated borders. In other cases the ulcer has been of considerable size and solitary. The diagnosis is to be made from the history in the chronic cases, from a long story of the discharge of pus, mucus, and blood from the rectum, of diarrhea and the symptoms already described, and further by inspection through one or other of the forms of rectal speculum. In the acute cases the symptoms are so characteristic as to be unmistakable, the only possible difficulties in diagnosis being the determination of the exciting cause, usually possible from the history.

Gonorrhea of the Rectum.—Gonorrheal inflammation of the rectum usually occurs from inoculation of a gonorrheal discharge from the vulva in females; occasionally the rectum may be the original seat of the infection. It is much more common among women than among men, and much more common among female children than among adults. The cases I have seen have nearly all been little girls in institutions and in hospitals. The manner of infection has usually been that the child has acquired gonorrhea for the most part in some inexplicable way, and that the inflammation of the vulva and vagina have spread to the rectum. In the hospitals in the city of New York, and in the institutions where children in large numbers are cared for, outbreaks of gon-

orrhea occur quite frequently; sometimes a large proportion of the children in such an institution will be infected at the same time, and that in spite of every possible precaution taken to prevent the spread of the disease, and under these circumstances gonorrhea of the rectum is by no means rare. The symptoms and signs of gonorrhea of the rectum among children are much more severe than is the case with adults. The child suffers with the symptoms of acute inflammation of the rectum—pain, straining, rectal tenesmus, and the discharge of pus and mucus, sometimes mixed with blood. Frequently the constant straining produces a certain degree of prolapse of the mucous membrane. The diagnosis is to be made from the examination of the discharge under the microscope for the gonococcus. These children are frequently quite ill; they suffer from severe pain, from fever, prostration, loss of sleep, and sometimes from one or other of the complications of gonorrhea. In adults the symptoms of gonorrhea of the rectum are apt to be less severe. The patients have the symptoms of a moderately severe catarrhal inflammation of the rectum, occasionally with the production of superficial erosions, fissures, or ulcerations. The diagnosis is to be made from the presence of gonorrhea of the genital tract and from an examination of the discharge for the gonococcus. The disease may assume in certain cases a chronic form, ending in thickening and induration of the mucous membrane of the bowel, and sometimes, it is stated, in stricture of the rectum. There is no means of differentiating gonorrheal inflammation of the rectum from simple catarrhal inflammation except by the discovery of the specific organisms of the disease.

Chancroid of the Anus and Rectum.—Chancroid of the anus and rectum, as is the case with gonorrhea, occurs much more frequently in women than in men, and usually from autoinoculation from a chancroid of the vulva, occasionally as a primary infection. As is the case with chancroid elsewhere, the disease is characterized by a short period of incubation or none, by the formation of multiple, acutely inflamed, progressive ulcerations with reddened edges, yellowish-white sloughy bases, a purulent discharge, marked pain and tenderness, and frequently painful enlargement of the inguinal lymph nodes. The ulcers occur for the most part outside of or just within the anus, rarely in the rectum proper. In debilitated persons, or if the poison happens to be particularly virulent, the disease may take on the phagedenic type. From time to time one sees in the hospitals of New York chancroids of the rectum and neighboring structures which have existed for years. I recall a case, seen while I was house surgeon in Bellevue Hospital, of a young negro man who had suffered from a chancroid for several years. The disease had gradually become very chronic, and except for the absence of marked induration suggested a very chronic form of epithelioma rather than any other disease. The ulcerated surface extended across the front of the abdomen above the pubes, involved the perineum, the greater part of the scrotum, had destroyed half of the penis, and extended up the rectum a distance of two inches. After a number of operations of a very extensive character this man was finally cured

Chancroidal ulceration of the rectum may, of course, be followed by cicatricial contraction and stricture.

Syphilitic Lesions of the Anus and Rectum.—The initial lesion of syphilis is rather rarely observed in the anus and rectum, more frequently in women than in men, and rarely within the rectum itself, but usually at the mucocutaneous junction of the anus. The chancre possesses the ordinary characters described elsewhere. The lymphatic enlargements affect the inguinal lymph nodes.

Secondary Syphilitic Manifestations of the Anus.—Moist papules and the so-called broad condylomata are very frequently observed around the margin of the anus. They occur as mucous papules having the characters already described, not in the sulci between the folds of skin, but along the intervening ridges, thus distinguishing them from simple fissure. They usually become covered with soft crusts of a pearly white appearance. When these mucous papules are numerous they frequently coalesce to form the so-called broad condylomata, whose true home is in this region. Very considerable tumors may be formed in this way, which might even be mistaken for cancer by the inexperienced (see Fig. 32). In the later stages of secondary or in tertiary syphilis there sometimes develops a dry and brittle condition of the mucous membrane and skin bordering the anus. Under these circumstances more or less painful fissures may occur, usually covered with pale and sluggish granulations. Pain and the symptom of itching are frequently present. It would be carrying me too far afield to describe at length all the possible secondary syphilitic lesions in this vicinity.

FIG. 32.—SECONDARY MOIST PAPULES (SYPHILITIC, FLAT CONDYLOMATA OF THE ANUS). (New York Hospital, out-patient department.)

Tertiary Syphilis of the Rectum.—Isolated gummata occur only very rarely in the rectum. Diffuse syphilitic inflammation of the rectum, on the other hand, is a very common lesion, and regularly leads to the subsequent production of stricture of the rectum. Indeed, a very large proportion of all the strictures of the rectum are due to tertiary syphilis. The patients are nearly always females. The disease begins with the formation of multiple syphilitic nodules in the mucous membrane, usually just within the rectum proper above

the external sphincter, and tends to spread upward, sometimes as far as the sigmoid flexure or even higher. As the disease progresses the nodules break down and gradually form ulcers, which coalesce. Infection of the raw surfaces takes place from constant exposure to intestinal contents, and there are added the symptoms of ordinary catarrh, sometimes of suppurative inflammation, with the formation of abscesses in the vicinity of the rectum, fistulæ, etc. Later in the disease inflammatory infiltration of the entire rectal wall takes place with the formation of abundant cicatricial tissue. Instead of ulcerated surfaces and pockets in the mucous membrane the rectal wall becomes converted into scar tissue, so that upon inspection one sees a dense, firm, white, rough or ridged, uneven surface, often completely surrounding the rectum, and extending a variable distance upward. In the earlier stages of the disease the symptoms are those of acute, or more commonly chronic, catarrh of the rectum, sometimes associated with pyogenic infection, fistulæ, and abscess, as already described. The disease may be very painful in a certain proportion of cases. During its earlier stages tertiary syphilis of the rectum often runs a somewhat latent course, and we do not see these patients until they come to us suffering with the symptoms of stricture of the rectum. A large part of the rectum may be converted into a rigid cicatricial canal. The diagnosis is to be made from a history of syphilitic infection, from the presence of other manifestations of tertiary syphilis, from the absence of the signs of malignant disease, and the fact that these individuals are usually younger than the cancerous age, although not always. (For further details, see Stricture of the Rectum.)

Tuberculosis of the Anus and Rectum.—Tuberculosis of the anus and of the rectum may occur in three forms: The first two are very rare, the third is exceedingly common. Infection may occur through the ingestion of tuberculous food—milk from tuberculous cows, for example—or from the swallowing of tuberculous sputum in cases of chronic phthisis, or occasionally from inoculation by scratching with infected finger nails. The first form of tuberculosis is lupus. This occurs upon the cutaneous margin of the anus and its vicinity. It does not differ in clinical characteristics from lupus in other situations, as already described. (See Lupus.) The second form, also extremely rare, is the warty or papillary form of tuberculosis. It consists of the formation of papillary outgrowths upon the skin and mucous membrane near the anus, consisting of tubercle tissue. The diagnosis must be made by the recognition of tubercle bacilli under the microscope. The disease may be confounded with beginning epithelioma of the anus, or possibly with acuminate warts. The coxcomb appearance of acuminate warts is absent, and the base of the papillary outgrowths does not show the characteristic induration of cancer. The third form, true tuberculous ulceration of the rectum, quite rarely occurs alone, but is nearly always associated with infection of the perirectal structures, and the formation of tuberculous fistula *in ano*. I have, however, personally seen a number of these cases, and have operated upon

several in which no fistula was present. They are nearly always associated with tuberculosis of the lungs. The diagnosis of the tuberculous ulceration of the rectum is to be made by the history of diarrhea, the discharge of mucus and pus, sometimes mixed with blood from the rectum, from pain, and from inspection of the rectal mucous membrane through a speculum. The appearance of tuberculous ulcers of the rectum does not differ from that of tuberculous ulceration in other mucous membranes. The ulcers are usually irregular in shape, their margins are frequently scalloped and undermined; the base of the ulcer is covered with pale flabby granulation tissue, exhibiting here and there small yellow dots, representing caseating tuberculous nodules. Sometimes areas of tuberculous infiltration may be seen in the surrounding mucous membrane not yet broken down. They have an inflamed border and a white or yellowish center. The diagnosis can usually be made from the presence of tuberculosis of the lungs or of other organs. In cases of doubt scrapings from the ulcer may be examined for tubercle bacilli, or inoculation of animals may be tried, the difficulty in these cases being that the animals are apt at the same time to be inoculated with the pyogenic germs and to die of septicemia. (See also Tuberculosis of the Intestine.) The question of surgical treatment of these cases will depend very largely upon the general condition of the individual and the extent and severity of the other tuberculous lesions, if such be present.

Painful Fissure of the Anus.—Small superficial ulcers, cracks or fissures in the mucous membrane or muco-cutaneous junction just within the grasp of the anal sphincter, situated in the sulci between the radiating folds of skin at the anal margin, are exceedingly common; their most frequent position is in the posterior commissure, and for the apparent trifling nature of the lesion these fissures give rise to symptoms of extraordinary severity. The causes of fissure of the anus are usually mechanical, and are due to injuries of the mucous membrane produced often by constipation and the passage of large fecal masses which mechanically injure the delicate epithelial covering. The disease is frequently associated with hemorrhoids, or it may be produced during labor; sometimes it is due to the passage *per rectum* of some small, sharp foreign body which has been swallowed accidentally—a fish bone or the like. It is sometimes associated with gonorrhea, syphilis, or chancroid of the anus. The disease usually affects adults, and women more commonly than men; no age is exempt. The ulcer is quite superficial in character, and usually lies hidden between the muco-cutaneous folds of the anal orifice; it is linear or oval in shape. The base may consist of a grayish-white raw surface which shows no tendency to heal; the edges are slightly inflamed; rarely much thickened and not indurated. It is usually impossible to see these ulcers without obliterating the folds of skin about the anus by traction on either side and asking the patient to bear down. Occasionally it is necessary to introduce a short tubular speculum, rarely to dilate the sphincter, before the fissure or ulcer is visible. Upon digital examination the presence of an exceedingly tender spot near the

anus becomes evident. The mere effort to introduce the finger causes violent spasm of the sphincter muscle, so that without a local or general anesthetic such introduction may be impossible. If the finger is introduced the patient will complain of intense pain, referred to the point of ulceration. The examination may be followed by the escape of a drop or two of blood. The symptoms produced by painful fissure of the anus are absolutely characteristic. The patient suffers intense pain when the bowels move, and this pain is more marked when the movements are large and hard. Following the movement of the bowels a continuous or intermittent spasm of the sphincter muscle occurs, lasting for minutes or hours, after which the patient is again comfortable until the bowels move again. The movement of the bowels may be followed by the escape of a few drops of blood. Sometimes the pain is not felt so much during the time the bowels are moving as afterwards. It is an intense and most annoying pain, attended by sudden acute exacerbations, caused by the involuntary spasmodic contraction of the sphincter muscle. The pain is described as being such as might be produced by the passage of a red-hot iron or a knife into the bowel. It is sharp and often agonizing. In bad cases it may be so severe as to produce syncope. The pain may be confined to the vicinity of the anus or may radiate in the back or thighs. In certain cases the pain is continuous, the individuals are constantly in a state of suffering and discomfort. These patients often fall into a neurasthenic or hysterical condition and become extremely wretched. When the ulcer consists of a mere superficial crack in the mucous membrane, it may, if the individual keeps the bowels freely open, last only for a few days or for a week or two, and get well of itself. In other cases the condition goes from bad to worse. The diagnosis is to be made from the very characteristic history and from the examination of the rectum and anus, if necessary under a general anesthetic; during the anesthesia the very simple curative measure of dilating the sphincter or incising the base of the ulcer may be performed.

Suppuration of the Tissues Surrounding the Rectum—Periproctitis.—One of the most frequent, if not the most frequent, diseases connected with the rectum is suppuration of the perirectal tissues. The causes are in the majority of instances infection through the mucous membrane of the bowel which invades the perirectal structures. Such may be caused by wounds or lacerations of the mucous membrane produced by the passage of hardened feces or by foreign bodies. Further, any one of the processes already described producing ulceration of the bowel. The infection and suppuration may occur in one of three situations. In the subcutaneous connective tissue in the vicinity of the anus which is continuous with the submucous tissue between the sphincter ani muscle and the mucous membrane. Second, in the ischiorectal fossa, a somewhat pyramidal space, which is bounded on the inner side by the external sphincter, above by the levator ani muscle, and on the outer side by the ischium. This space is filled with loose connective tissue containing much fat, and the spaces of the two sides are more or less completely separated

by a septum of connective tissue. The third space lies above the levator ani muscle, surrounds the rectum, and lies between the peritoneum above and the levator ani muscle below. This space is more or less completely divided by connective-tissue septa into an anterior and posterior rectal space. It is, as stated, separated from the ischiorectal fossa by the levator ani muscle. Perirectal suppuration may be diffuse or circumscribed. The diffuse form occasionally runs an acute and fatal course. It follows extensive operations upon the rectum or accidental injuries, notably severe lacerated wounds. It is that sudden violent form of septic phlegmonous inflammation already described in the chapters devoted to the diseases of wounds. Following an operation or an injury in the vicinity of the rectum; the tissues of the ischiorectal fossa or, if the wound or injury extend above the levator ani muscle, the retroperitoneal tissues; sometimes also the skin of the buttocks, the perineum, the scrotum, etc., undergo a rapid, progressive, septic, and necrotic destruction. The patients do not survive this condition, and die, with progressive septic symptoms, exhausted, in from two or three days to a week. This form of inflammation is occasionally seen after the operation of prostatectomy in old and feeble men. The streptococcus, and occasionally the staphylococcus, are the organisms ordinarily concerned in the process. Another form of septic inflammation of the perirectal structures was especially described by Kraske, caused usually by the Bacillus coli communis, and attended by the production of gas in the tissues. The condition is as follows: The temperature is only slightly elevated, the physical signs of inflammation are trifling, usually only a little edema in the subcutaneous and intermuscular tissues. Gradually, however, there occurs subcutaneous emphysema and small abscesses, containing gas with necrotic walls. The patient suffers from the symptoms of septic intoxication, the wound healing is imperfect, or the tissues exhibit no reaction whatever. The symptoms of stupor, mental depression, and apathy are usually marked. The condition is usually fatal. Further, a diffuse gangrenous form is described usually associated with diabetes. (Bacillus aërogenes capsulatus may be responsible for the more rapidly fatal forms.)

Circumscribed Inflammations of the Perirectal Structures.—These may be divided into superficial abscesses, abscesses in the ischiorectal fossa, and abscesses in the perirectal connective tissues above the levator ani muscle. The *superficial abscesses* develop beneath the skin at the margin of the anus; they may spread into the ischiorectal fossa or upward beneath the mucous membrane to a level above the external sphincter. They are to be recognized by the ordinary signs of acute abscess in this vicinity.

Ischiorectal Abscesses.—The most common source of infection is through the mucous membrane of the bowel, occasionally from external injuries, sometimes from purulent foci of other organs in the vicinity. They are accompanied by septic symptoms—pain, difficulty in moving the bowels, tenderness, induration, sometimes edema and redness of the skin to one side of the perineum, constipation, occasionally retention of urine. The diagnosis is to be made

by inspection of the buttock, which in the later stages will show an area of tenderness, a brawny edema, redness, and later fluctuation. By digital examination of the rectum, when a tender, boggy area will be felt outside the mucous membrane of the bowel; and by bimanual examination, the other hand being placed upon the skin of the buttock, an inflammatory mass is usually

FIG. 33.—ISCHIORECTAL ABSCESS. (New York Hospital, author's service.)

easily made out, hard and resistant, or sometimes fluctuating. It is to be borne in mind that digital examination of the rectum is of the utmost consequence in making an early diagnosis of these abscesses. If the surgeon waits until evidences of infection of the skin of the buttock are present, the disease may have extended widely in the deeper tissues, and the convalescence of the patient following operation will be so much the more delayed. Tuberculous abscesses occur also in the ischiorectal fossa. They are characterized by their painlessness, slow development, and the absence of the signs of acute suppuration, assuming that there is no mixed infection with pyogenic microbes.

Abscesses Situated above the Levator Ani Muscle.—The causes may be similar to those just described in the ischiorectal fossa. They not infrequently follow untreated abscesses of the prostate. Sometimes the infection descends from above, and is due to the suppuration of pelvic retroperitoneal lymph nodes; sometimes to diseases of bones of the pelvis or the spinal vertebræ. When due to ordinary pyogenic infection, they are apt to run a severe and stormy course with profound septic symptoms, and are often fatal. The diagnosis is to be made by careful rectal examination. When they run a more chronic course, they are apt to burrow in various directions; they may present in the

skin of the buttock, in the perineum, in the scrotum; they may rupture into the urethra or the bladder.

The abscesses arising in the subcutaneous or submucous tissues near the anus are to be treated by a simple incision, the direction of which should radiate from the anus with preservation of the sphincter. Abscesses in the ischiorectal fossa are to be opened by a large incision, usually vertical, parallel with the sphincter. Abscesses originating in the prostate are best opened by a semilunar cut in front of the anus, extending from one ischial tuberosity to the other, if necessary, and reaching the abscess by separating the rectum from the urethra.

Fistula in Ano.—The various suppurative processes just described as occurring in the perirectal structures have this peculiarity—namely, that *sometimes* after the abscess has been opened by suitable incision, and *usually* if the abscess has been allowed to rupture, the healing process proceeds up to a certain point, but remains incomplete; a sinus remains behind, surrounded by dense scar tissue and lined by granulations, sometimes partly by epithelium, opening through the skin in the vicinity of the anus; or into the bowel through the mucous membrane without any opening through the skin, or forms a channel opening at one end upon the skin, at the other into the bowel. Or in combination with one or other of these forms, more or less complicated chronic suppurating channels remain, running upward beneath the mucous membrane of the gut, or surrounding the anus in a horseshoe shape, or burrowing irregularly in various directions. These various conditions are known by the name of *anal fistula, fistula in ano*, and, since they are among the commonest of surgical lesions, a thorough understanding of them is not only interesting, but also important, in order that they may be intelligently treated. As has already been stated, many of these suppurative processes are caused by the ordinary pyogenic microbes, but a very large proportion of them are due to infection with Bacillus tuberculosis—about ten per cent; rather rarely they occur as a complication of tertiary syphilis of the rectum. The disease occurs for the most part during middle life, is rather more frequent among men than among women. In the tuberculous cases the formation of a fistula may be the first evidence of tuberculosis in the infected individual; more commonly, however, signs of pulmonary phthisis will be discoverable. It is customary to classify these fistulæ under several types, and the classification is important from a diagnostic as well as a therapeutic point of view. When a fistulous tract has two openings, one upon the skin and one upon the mucous membrane of the bowel, it is known as a *complete fistula*. When an *external* opening exists, but no *internal* one, it is called an *incomplete or blind external fistula*. When an *internal* opening through the mucous membrane is present, but *none* upon the skin, the condition is known as an *incomplete or blind internal fistula*. When several openings and irregular burrowing channels are present, *a complicated fistula* exists. It is also important to distinguish the course of the various types of fistulæ with reference to anatomical structures (see Fig. 34). These, in general, correspond to the situation of the original abscess: (1)

Those resulting from superficial abscesses, the most common form, run beneath the skin or mucous membrane respectively, and open internal to the sphincter close to the anal margin, upon the skin, or just above the external sphincter upon the mucous membrane, or both. (2) The ischiorectal type:

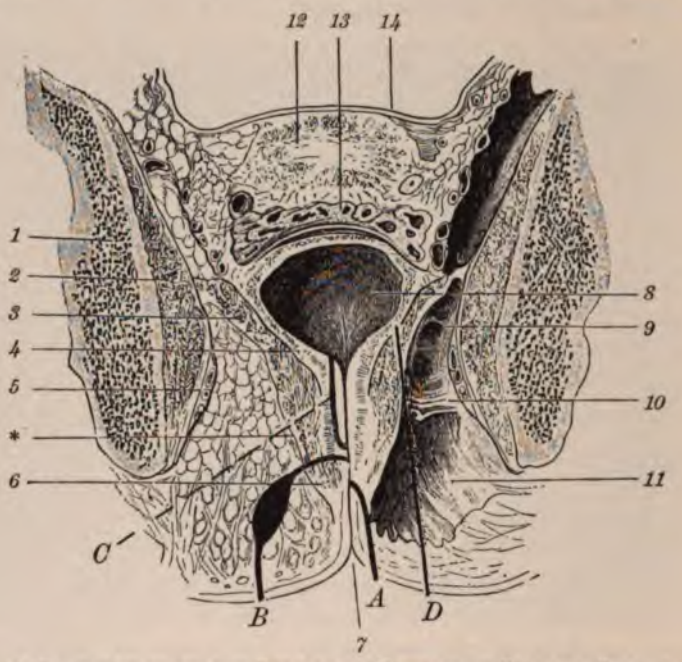


FIG. 34.—FRONTAL SECTION THROUGH THE PELVIS OF A FORMALIZED CADAVER, SHOWING THE RECTUM, THE ISCHIORECTAL FOSSA, AND THE ARRANGEMENT OF THE MUSCULAR LAYERS OF THE PELVIS. At *A* is indicated the course of a complete fistula opening upon the skin of the buttock externally and upon the mucous membrane just below the external sphincter. At *B* is shown the course of a complete fistula opening externally upon the skin of the buttock, passing upward through the fat of the ischiorectal fossa. The tract enters the bowel beyond the external sphincter. At *C* is shown a blind internal fistula running beneath the mucous membrane. The internal opening is in the ampulla of the rectum. There is no external opening. At *D* is shown the course of a fistula opening externally upon the skin of the buttock and passing upward to penetrate the levator ani muscle ending above in the connective tissue planes separating the levator ani from the wall of the rectum. Such fistulous tracts proceed occasionally from intrapelvic foci of suppuration, as indicated in the text.

1. Pelvic bone. *2.* Obturator internus muscle. *3.* Levator ani muscle. *4.* Pelvic fascia. *5.* Internal pudic vessels and nerve. *6.* External sphincter. *7.* Anus. *8.* Ampulla of the rectum. *9.* Ischiorectal fossa. *10.* Urogenital diaphragm. *11.* Ischiorectal fossa from which the fat has been removed. *12.* Urinary bladder which has been stripped upward. *13.* Seminal vesicles. *14.* Peritoneum. (After Merkel.)

These are less common than type one. The external opening is upon the skin of the buttock in the ischiorectal space—i. e., outside the external sphincter. The internal opening, often absent, opens into the gut above the external and below the internal sphincter—i. e., between the two—according to Allingham, in ninety per cent of the cases. More rarely higher up in the bowel above the internal sphincter. (3) Fistulæ arising from abscesses above the levator ani: This type is relatively rare, and quite commonly arises from abscesses of the prostate, occasionally from suppuration of the seminal vesicles. The commonest site for the external opening is in the perineum in front of the anus;

ss commonly the sinus opens upon the skin of the buttock outside the exter-al sphincter in the base of the ischiorectal space. The internal orifice of the uperficial fistulæ, group one, lies very often in one of the sinuses of Morgagni. The external orifice lies close to the anus at its cutaneous margin, and is often partly hidden by one of the cutaneous folds. The external opening of the ischiorectal fistulæ lies usually to one side of the anus, and may be removed a considerable distance from the anal orifice far out upon the buttock. The complicated fistulæ arise for the most part from neglected cases of ischiorectal fistulæ. The retention of the discharges, the formation of new abscesses, which burrow beneath the skin and rupture in a new place, usually through the skin to one or other side of the anus, rarely through the mucous membrane, may, after a time, riddle the skin of the buttocks with fistulous tracts which have been likened to a rabbit warren. Such conditions are sometimes seen in old and feeble persons and in tuberculous cases. They are incurable by operation under the conditions mentioned. A not infrequent condition is that the anus is circumscribed by a fistulous tract of a horseshoe shape. The canal in those cases usually passes posterior to the anus. Spontaneous healing of *fistula in ano* is prevented by a variety of circumstances. In tuberculous and syphilitic cases the nature of the process does not tend to spontaneous cure. In complete fistulæ the continued entrance of infectious material from the bowel furnishes a constant source of irritation. The frequently tortuous and rigid fistulous canals are unfavorable for proper drainage. The action of the sphincters forbids the continued rest of the parts usually necessary for the healing process.

Symptoms and Diagnosis of Fistula in Ano.—The severity of the symptoms and degree of annoyance suffered varies a good deal, according to the character of fistula. The incomplete external fistulæ cause often merely a certain degree of discomfort. The patient suffers from the annoyance of the discharge of a small amount of pus, he has some itching, irritation of the skin, a sensation of wetness, and slight staining of the clothing. If the orifice is plugged, he will have some pain and discomfort, painful defecation, etc., until the small collection ruptures at or near the former orifice; some pus will then be discharged, and he will be relieved, and remain so until retention again occurs. The complete fistulæ are still more annoying. There is more discharge of pus and feces, sometimes of gas through the fistula. Pain on defecation, irritation of the skin, and soiling of the clothing is more marked. The incomplete internal fistulæ are characterized often by more or less intermittent symptoms, the patient will suffer from more or less constant discomfort in the rectum, made worse by defecation, and from time to time will have an increase of pain and discomfort when retention of pus occurs in the pocket, accompanied by tenesmus. After a time the collection will discharge itself into the rectum; the patient will pass mucus, pus, and sometimes blood in considerable quantity, and have temporary relief. The *diagnosis* of *fistula in ano* is made from the history and the examination of the anal region and rectum. In the

ordinary pyogenic cases the external orifice is often very small, and may be represented by a minute dimple or pucker in the skin, perhaps only visible on obliterating the cutaneous folds by traction. Pressure with one finger in the bowel may cause the escape of a drop or two of pus from the external orifice. Often there will be a small inflammatory papilla upon the skin with a minute central orifice. In tuberculous cases such a papilla may be crowned with typical tuberculous granulations. A finger introduced into the bowel often permits one to feel one or more hard cords leading from the cutaneous orifice to some point in the mucous membrane, where a minute depression or a papillary hard prominence can be detected. In tuberculous cases the internal orifice is often at the bottom of an ulcerated area of some size. The finger may be withdrawn and a flexible probe introduced very gently through the cutaneous opening, when reintroduction of the finger may permit the probe to be felt in the bowel or in the blind external fistulæ just beneath the mucous membrane, and usually this will be at a point opposite the upper border of the external sphincter. The blind internal fistulæ may sometimes be detected by the sense of touch, sometimes by inspection through the tubular speculum of Kelly (sphincteroscope), sometimes only under a general anesthetic after the sphincter has been dilated. The complicated fistulæ will usually require a general anesthetic to enable one to trace out their ramifications. R. T. Morris is in the habit of injecting the fistulous tracts with plaster-of-Paris cream at the time of operation, thus permitting an accurate dissection of their various ramifications. Dr. Morris informs me that the cases suitable for this method are those: (1) Where a considerable fistulous pocket exists. (2) Where the fistulous canals are fairly wide. (3) Where the canals can be kept free from blood—i. e., blood interferes with the hardening of the plaster. They may be washed out with salt solution before injecting the plaster. Personally, the diagnosis of *fistula in ano* having been made from the history, the presence of an external orifice, and by digital rectal palpation, I prefer to avoid the introduction of a probe until the patient is under ether and ready for operation. The danger of septic absorption from the trauma caused by the probe is thus avoided. As has already been indicated in other sections of this book, the use of a probe in suppurating sinuses is by no means free from risk. This was pointed out by Senn many years ago. When a fistula exists in the perineum or in the posterior part of the ischiorectal region, it may have originated in the prostate; much more rarely from disease of the pelvic bones or vertebræ. In these cases the history will usually enable one to exclude ordinary *fistula in ano*, and will probably point to some entirely different type of disease—prostatic abscess, stricture of the urethra, sacro-iliac or Pott's disease, pelvic abscess, etc. In these cases introduction of a probe at the time of operation will lead not to the rectum, but to some other structure, sometimes high up in the pelvis. The nature of the lesion in the given case must be determined by concomitant signs and symptoms to be found described under appropriate headings in this book.

STRICTURE OF THE RECTUM AND ANUS

Narrowing of the anal orifice may, as already mentioned, occur rarely as a congenital condition. Acquired stricture of the anal orifice may follow accidental wounds with loss of substance or sloughing of the tissues bordering the anus from any cause; or surgical operations, notably Whitehead's operation; further, extensive operations for *fistula in ano* with the production of much cicatricial tissue, excessive cauterizations for piles, ulcers, etc., gangrenous, ulcerative, and suppurative processes of all kinds in the vicinity of the anus may be followed by stricture. Further, cancer of the anus. The diagnosis of the condition presents no difficulties. The individual suffers from difficulty in moving the bowels; straining is necessary. If ulcerated surfaces are present there will be pain. The movements are tapelike or smaller than normal. Physical examination with the finger or with a rectal bougie reveals the condition at once.

Stricture of the Rectum.—Stricture of the rectum proper is much more frequent than stricture of the anus. The causes may be *extrinsic*—i. e., pressure upon the bowel from without by tumors or exudates, or *intrinsic*, due to affections of the bowel itself. The extrinsic causes seldom lead to absolute obstruction unless they finally actually involve the wall of the gut—as, for example, invasion of the rectum by cancer of the uterus or ovary. Benign tumors, myomata, ovarian cysts, etc., while they may compress the rectum and cause a high grade of constipation, never cause absolute closure of the gut. The chronic forms of pelvic peritonitis with dense and massive adhesions and the production of much new-formed connective tissue, such as one sees as the result of chronic gonorrhea with pus tubes, ovarian abscess, etc., not infrequently compress the caliber of the bowel and produce obstinate constipation; rarely such a degree of compression as to produce symptoms threatening intestinal obstruction. A similar condition may occur in cases of tuberculous peritonitis. The diagnosis is to be made from the presence of a pelvic tumor or exudate, as the case may be; from digital examination of the rectum, and from inspection of the interior of the bowel in the knee-chest position after the introduction of a suitable tubular speculum illuminated by an electric headlight, etc. The introduction of bougies in these cases does not usually give accurate information. The intrinsic causes of stricture of the rectum are: First and most frequent, *cancer* of the rectum. The rare congenital strictures of the bowel, as already described. The stenoses of the sigmoid and rectum produced by inflammation in acquired diverticula is a lesion of rather rare occurrence, to which the attention of surgeons has been attracted only during the last few years. Isolated cases of the condition have been described from time to time by Jones in 1858, by Loomis in 1877, and by several other observers. Papers were read on this topic at the meeting of the American Surgical Association, in 1907, by G. Brewer and Mayo. There are now more than thirty reported cases. Rotter and Grasser observed and studied four cases.

Their patients died as the result of acute or chronic intestinal obstruction, the diagnosis being only made after death. The lesions consisted of the formation of numerous small false diverticula of the mucous membrane of the bowel (pelvic colon and sigmoid flexure) projecting into the mesentery, following the course of dilated mesenteric veins, owing their presence in these cases to systemic venous congestion from heart disease, accumulation of fecal matter in these minute pouches, inflammation, perforation, and the formation of minute abscesses and suppurating tracts in the subserous tissue, and especially in the intramesenteric connective tissues of the bowel. These processes resulted finally in the production of much scar tissue, involving the lumen of the gut over an area varying in extent from 5 to 20 cm. The mucous membrane of the bowel over this area lay in creases and folds, and was, with the exception of the sites of the minute diverticula, normal. The case of Dr. C. F. Collins, quoted in speaking of Chronic Obstruction of the Large Intestine, was doubtless of this description. In some of the reported cases a peridiverticulitis has followed, with the formation of an inflammatory mass, usually upon the left side of the abdomen and low down. In some cases perforation and diffuse peritonitis have followed, in others a more or less distinctly localized abscess. It is scarcely possible to make a definite diagnosis of these conditions before opening the abdomen.

A variety of rather unusual traumatic causes may produce stricture of the rectum: Sloughing of the mucous membrane of the bowel following labor; traumatisms with loss of substance of the mucous membrane; cauterizations with boiling water, or the accidental injection of caustic fluids into the rectum. These are true cicatricial strictures, and vary in form, situation, and extent, according to accidental conditions. The strictures produced by malignant disease are described under Cancer of the Rectum.

Inflammatory Strictures of the Rectum, due to Chronic Inflammatory Lesions of the Mucous Membrane of the Bowel.—The following causes of inflammatory stricture of the rectum may be enumerated: Simple chronic catarrhal inflammation, gonorrhea of the rectum, *tertiary syphilis*, very rarely tuberculosis; dysenteric ulceration, believed at the present time to be a rare cause; other possible causes are mentioned by various observers; pressure ulceration of the bowel by hardened masses of feces; rupture of an abscess of Bartholin's gland into the rectum. Recently I have observed a ring-shaped stricture of the rectum just above the external sphincter following the rupture of a prostatic abscess into the bowel. The stricture at the present time is not tight enough to produce marked symptoms. It admits the terminal phalanx of the index finger. The situation of stricture of the rectum is usually low down near the anus, more rarely two, three, or four inches above this point. The strictures are usually single, and vary in length from a narrow ring a quarter of an inch wide up to tubular strictures several inches long, or even involving the entire rectum as far as the sigmoid. The caliber of the stricture varies, as in other cicatricial contractions of mucous canals, with its

age. During its early stages, while the inflammatory process has not as yet ended in the production of massive areas of scar tissue involving all the coats of the gut, the narrowing will be slight, but the end result, from whatever cause the stricture has occurred, is the same. The rectum is converted throughout a greater or less extent of its length into a rigid tube of scar tissue, through which extends a canal admitting a finger, or in extreme cases so small that a uterine sound passes only with difficulty. The mucous membrane below the stricture is always in a state of chronic inflammation; fissure of the anus, abscesses, and fistulæ are frequent complications. It is believed that *syphilis* and gonorrhea of the rectum are the most frequent causes of stricture, and since these lesions of the rectum are far more common in women than in men we find stricture of the rectum nearly five times as frequent in the female sex.

Symptoms and Diagnosis of Inflammatory Stricture of the Rectum.—In every case there will be a history of chronic catarrhal inflammation of the rectum. To recapitulate the symptoms of this disease, they are the discharge from the rectum during defecation of mucus and pus, sometimes of blood, usually pain and rectal tenesmus. The discharge of pus, etc., is especially noticeable in the morning stool, and the patient is obliged to evacuate the bowel at once upon rising in the morning. If no considerable discharge of pus and mucus occur alone, the movements, if solid, will be found coated with mucus and pus. As the disease progresses and the bowel becomes narrow, the patient will suffer from increasing difficulty in defecation. Straining at stool, constipation, only relieved by keeping the stools fluid or semisolid, will occur, alternating in some cases with diarrhea. The shape of the stools may be changed. If the stricture is low down, they may be tapelike, or at least of very small size. If higher up, the stools may resemble the droppings of goats and deer—i. e., small cylindrical or ovoid masses. In other cases when the stricture is above the ampulla, feces will accumulate in the ampulla, and be discharged *per anum* of normal size. As the result of the accumulation of fecal matter in the colon above the stricture, dilatation of the bowel often occurs, and the absorption of retained decomposition products leads to disturbances of digestion, a coated tongue, gastric dyspepsia, headaches, a foul breath, nausea, and a tympanitic belly. Colicky pain, often attended by subjective sensations of increased peristalsis and audible gurgling in the bowels, is a common symptom, anemia, and not infrequently a sallow and cachectic appearance of the countenance, suggesting malignant disease. *A condition very suggestive of stricture of the rectum or of cancer is chronic diarrhea of a peculiar type.* These patients have frequent small diarrheal movements, preceded by rectal pain and tenesmus. The stools are small and watery, and are mixed with mucus and pus, sometimes a little blood. Pain of a distressing, even agonizing, character precedes, accompanies, and may follow each movement. When the stricture involves the level of the sphincter, incontinence of feces may be present. The course of the disease is exceedingly chronic, extending often over many years, and slowly growing worse. If not relieved by operation these

patients may die, exhausted, of chronic intestinal intoxication, of intestinal obstruction, or of some complication or intercurrent disease—pneumonia, for example—or if the stricture leads to perforation and the formation of perirectal abscess and sinuses, they may die of chronic septic absorption. The diagnosis of stricture of the rectum is very simple, if the stricture is near the anus. If high up, so that the narrowed portion is beyond the reach of the finger, it may not be so easy. In the former group of cases, given a history of chronic rectal catarrh, together with the group of symptoms just outlined, the digital examination of the rectum reveals the presence of an obstruction of a dense, hard cicatricial character at once. Inspection through the sphincteroscope reveals a chronic inflammation of the bowel below the stricture, often with a thickened granular mucous membrane. The dense white scar tissue of the face of the stricture itself, often funnel-shaped and denuded of mucous membrane and quite typical of an exceedingly chronic inflammatory process in its end stages, is readily distinguished from cancer, the characters of the latter being a rough, nodular, *bleeding*, ulcerated surface, often sloughing and putrid; marked hemorrhages in ninety per cent of the cases, the age of the patient and other characters to be described under Cancer of the Rectum. In the cases of deep-seated stricture of the rectum—i. e., beyond the reach of the finger—there are two methods of examination, either or both of which may be useful: First, examination of the rectum with bougies and similar instruments. Second, examination with the proctoscope or sigmoidoscope respectively. As already suggested, digital examination with the patient in the erect or squatting posture, while he is told to bear down and strain as hard as may be, enables the surgeon to reach an inch or more farther up the bowel. Examination with bougies may be conducted with the patient in the left lateral (Sims's position) or in the lithotomy position with elevated pelvis. The bowel should be washed clean before the examination is made, and if the stricture be very narrow the amount of fluid readily injected may give the surgeon a general idea of the site of the stricture, or, on the other hand, may render it more or less probable that no stricture is present in the rectum at all. A variety of bougies are used in examining the rectum. The most useful are cylindrical metal bougies with a curve corresponding to the anterior surface of the sacrum, Credé's rectal bougie, and olivary bougies of various sizes made of hard rubber or metal, so that they may be boiled, on long handles of whalebone or flexible metal. The several sized olives may be screwed on the same handle. These are, in fact, the bougies à boule, such as are used for the detection of urethral strictures and in examining the esophagus, but of larger size. The diameter of the various cylindrical and olivary bougies may vary from, say, a 20 French sound up to an inch. When using them they should be sterile and well lubricated. The soft rubber and silk bougies saturated with shellac or some similar substance are less useful. They are soon destroyed by boiling, and do not transmit so well to the hand holding them the sensations from which the physical conditions of the bowel may be

inferred. In passing bougies for the diagnosis of stricture of the rectum it is better to avoid the use of an anesthetic, for the reason that the sensations of the patient are a valuable guide to the seat of ulcers and painful points; further, that the surgeon will be less likely to use undue force, and thus possibly wound or even perforate the wall of the bowel sometimes weakened by ulceration and inflammation. The utmost gentleness should be used in their introduction, and the surgeon should remember that a mere sense of obstruction met with by no means indicates a stricture; such may be and often is due to catching the point of the instrument in a fold of mucous membrane or to an improper direction given to its point. If obstruction is met with the instrument should be withdrawn a little, the direction of its point changed slightly, and again advanced. Here, as in the urethra, the examination should be commenced with a large instrument, since such an one is much more less apt to catch in a fold of mucous membrane, and if that fails to pass, smaller instruments may be substituted until one is found which engages and passes through the stricture. Once through the stricture, the instrument is felt to be firmly grasped, and motion in either direction is restrained by the firm cicatricial mass surrounding it. *This is the diagnostic sign to be sought, and without it the diagnosis is not made.* In the case of olivary bougies, the instrument, once through and beyond the stricture, can be moved freely in the bowel above, but when withdrawn it again falls within the grip of the rigid stricture, which it passes with a distinct sense of resistance, as though riding over a bump—if I may use the expression which appears to me to convey most accurately the sensation transmitted to the hand. By means of olivary bougies the length of the stricture may be detected quite accurately. The late F. N. Otis devised an instrument for measuring the length and caliber of rectal strictures identical in principle and construction with his well-known urethrometer (see Urethra), but of larger size. It was a useful instrument in special cases; but the olivary bougies answer every purpose. In order that no mistake may be made, it is well to repeat the examination when any doubt at all exists as to the presence of true stricture. By the use of the proctoscope also the diagnosis of stricture of the rectum may be made quite accurately, and the character of the stricture studied. Thus we may often readily differentiate strictures due to extrinsic causes, adhesions, the presence of tumors, etc., from those due to disease of the wall of the gut itself. Rarely, as in a case mentioned by Kelly, a combination of the two causes may be present. In this case a large tubal abscess had ruptured into the rectum, at the same time causing stricture by pressure. The examination is made in the knee-chest position, as already described.

HEMORRHOIDS (PILES)

The word hemorrhoids, which signifies something from which blood flows, is the name given to a very common disease of the blood-vessels in the vicinity of the anus, the most characteristic symptom of which is bleeding. The

lesion of the disease is a dilatation of the veins of the hemorrhoidal plexus inferior or superior, or both. The most recent investigations into the patholo of the condition seems to indicate that in many cases, at least, hemorrhoids a true cavernous angiomata attended by the formation of new blood-vessels i and beneath the mucous membrane of the bowel, and not merely a varicos condition of the hemorrhoidal veins, as was formerly supposed. Clinically tw forms of the disease may be distinguished, although both are often associated in the same case, *external* and *internal hemorrhoids*. They differ in situation and symptoms. External hemorrhoids develop in the inferior or subcutaneous plexus of hemorrhoidal veins, those emptying into the internal pudic veins, and thence into the inferior vena cava. These veins lie beneath the muco-cutaneous covering of the anal orifice, internal to the external sphincter, and the plexus extends up the bowel as far as the so-called white line already mentioned, or opposite to the lower border of the internal sphincter. The internal hemorrhoids lie in the submucous tissue, and consist of veins belonging to the superior hemorrhoidal plexus, above the external sphincter. They frequently occupy the situation of the columns of Morgagni. A hemorrhoid or hemorrhoidal nodule consists of more or less dilated veins, sometimes distinctly varicose and with lateral diverticula and pockets of various shapes and sizes embedded in a connective-tissue framework and covered by skin or mucous membrane, as the case may be. The internal hemorrhoids, being covered with mucous membrane, show the presence under the microscope of numerous dilated capillaries upon their surfaces. The veins which go to make up an internal hemorrhoid are usually much more numerous than is the case with the external kind, and the veins of the former are smaller and do not exhibit such marked deformities in shape. Although, as stated, modern pathology groups many cases of hemorrhoids, notably of the internal type, with the cavernous angiomata, many external hemorrhoids and those internal hemorrhoids which are caused purely by venous congestion due to the pressure of tumors, to pregnancy, to cirrhosis of the liver, heart disease, and similar conditions, are probably merely varicose dilatations of preformed veins. The causes of hemorrhoids are first and foremost constipation and straining at stool. The veins being valveless, a considerable weight of blood must be maintained between the anus and the liver, and this predisposes to dilatation. The erect posture of human beings is supposed to account for the much greater frequency of hemorrhoids in man than in the lower animals. Anything which interferes mechanically with the return of blood through the portal system, the gravid uterus, tumors of all kinds in the pelvis or in the abdomen, or inflammatory exudates which press upon the veins of the portal system, may produce hemorrhoids, and further general disturbances of the venous circulation, such as follow chronic disease of the heart and lungs. Hemorrhoids are extremely common among civilized races, and it is said, very rare among savages. The disease occurs for the most part during adult life, and is rare in children. It is more frequent in men than in women.

Symptoms and Diagnosis of External Hemorrhoids.—External hemorrhoids form tumors visible upon inspection of the anal region. They vary in size from that of a bird shot to tumors as large as the last joint of one's finger. When recent they are blue in color and are sessile, the broad base being attached to the muco-cutaneous surface. When older the integument becomes thickened by attacks of inflammation, and the characteristic blue color of the blood shimmering through the thin-walled vessels is lost. When recent they increase in size when the patient strains downward or squats, diminish in size on pressure, but are not reducible into the bowel. The symptoms produced by external hemorrhoids are usually only marked when a thrombophlebitis occurs in the dilated veins. Such a condition is known as *an attack of hemorrhoids.* The nodule or nodules become swollen, tender, and very painful; there may be a sensation of throbbing felt in the perineum; there is frequently spasmodic contraction of the sphincter muscle, and often the patient has a sensation as though there were a foreign body in the anus. The diagnosis is very readily made by inspection. In most cases the attack of inflammation subsides in a few days, and leaves merely a soft or somewhat firm tab of pendent skin at the margin of the anus, most frequently at the posterior commissure. In other cases the inflammation ends in suppuration, the formation of an abscess which ruptures or is incised. Such an abscess may leave a painful fissure of the anus behind.

Symptoms and Diagnosis of Internal Hemorrhoids.—The symptoms of internal hemorrhoids are quite different. They form solitary or more often multiple sessile soft tumors within the rectum. There may be but one such tumor, or in many instances there will be an entire circle of hemorrhoidal nodules at the level of the lower border of the internal sphincter muscle. In a good many cases internal hemorrhoids produce scarcely any symptoms at all. The patient may simply have an occasional sense of slight fullness or discomfort in the rectum, notably when at stool, with perhaps a very little bleeding from time to time. In other cases the symptoms will be more marked. The most important symptom of internal hemorrhoids is bleeding. The bleeding occurs during defecation or thereafter. It may be very small in amount, scarcely noticeable, or may amount to a teaspoonful or so, or in some cases the patient may suffer from very severe bleeding indeed. Even a small amount of blood if lost at every defecation will produce in time a profound degree of anemia, and some of the most anemic individuals I have ever seen have been cases of neglected internal hemorrhoids. The mucous membrane covering the hemorrhoids is usually very thin, contains dilated capillaries, is frequently in a state of catarrhal inflammation, and bleeds at the slightest touch. In the bad cases, if the patient becomes constipated and is obliged to strain violently, one or more of the dilated veins may be ruptured, and a hemorrhage may occur so severe as to threaten the patient's life. Another important symptom of internal hemorrhoids is their tendency to become prolapsed during defecation. In some cases one or more of the tumors will escape every time the patient has a move-

ment from the bowels and will have to be replaced. In other cases, and notably if the hemorrhoids are multiple, they will become prolapsed as the result of straining and be caught below the grasp of the external sphincter, so that they cannot be returned. Interference with the venous circulation causes the hemorrhoids to swell; they sometimes become infected and inflamed, and may even undergo suppuration or gangrene. Under these conditions very severe local and constitutional symptoms may occur. The hemorrhoids become the seat of a septic thrombophlebitis, the patient suffers from fever, prostration; the swelling at the anal orifice may be so great that defecation is seriously interfered with, so that nausea and vomiting and distention of the bowel may occur. In addition, these patients suffer from agonizing pain and a constant desire to defecate. Upon inspection one sees the anal orifice everted and surrounded by a row of eroded reddish-blue inflammatory tumors, intensely sensitive, and which bleed readily. Occasionally the entire mass becomes gangrenous, the piles slough away and leave an ulcerated surface behind, which

FIG. 35.—GANGRENOUS, PROLAPSED, AND STRANGULATED INTERNAL HEMORRHOIDS. Spontaneous cure followed prolonged rest in bed. (New York Hospital, service of Dr. L. A. Stimson.)

may heal, producing a kind of natural cure of the disease, or may lead to the formation of chronic ulceration or to stricture of the anus. Pyemia and death in these cases is not a very rare occurrence.

Nearly all the cases of internal hemorrhoids which give rise to definite symptoms are accompanied by a chronic catarrh of the rectum with the passage of mucus and pus, rectal tenesmus, and the symptoms already described when discussing this condition.

The *diagnosis* is usually easy. In the external variety inspection of the

anal region, together with the characteristic symptoms, is all that is necessary. Internal hemorrhoids can usually be diagnosticated from the history of bleeding and of the prolapse of the hemorrhoidal tumors during defecation. In order to render the diagnosis certain the surgeon during his examination requests the patient to bear down and at the same time gently spreads with his fingers the anal orifice. This is usually sufficient to cause one or more of the hemorrhoids to protrude. If not, the patient may be requested to assume a squatting position and to strain, when the tumors will usually protrude. If this does not suffice the finger may be inserted into the rectum, and while the patient strains the surgeon makes beckoning motions with his finger and coaxes one of the hemorrhoids out of the anus; or the patient may be given a small injection of glycerin, or a glycerin suppository may be introduced into the rectum, and the patient be directed to sit for a few moments upon the water-closet. Rectal palpation should never be omitted in these cases, because, although the diagnosis of hemorrhoids may be plain enough, they are often complicated by other and more important diseases: cancer or stricture of the rectum, or polypi. It is by no means easy to feel a noninflamed internal hemorrhoid by simple palpation with the finger. In case the hemorrhoids cannot be made to appear at the anus, a tubular speculum may be inserted, when the corrugated, blue, spongy-looking masses which constitute an internal pile will be readily visible. In order to estimate the exact size, number, and situation of internal hemorrhoids not already prolapsed, it is frequently necessary to administer a general anesthetic and to dilate the sphincter, when the conditions become entirely evident. When a patient presents himself with internal hemorrhoids it is always wise to seek some general or local cause for the condition: a tumor in the pelvis, pregnancy, cirrhosis of the liver, heart disease, or some other condition which tends to create venous congestion.

PROLAPSE OF THE ANUS AND PROLAPSE OF THE RECTUM

Under a variety of conditions the mucous membrane of the anus may protrude, notably when thickened or inflamed, as has already been described under Hemorrhoids. As was stated in speaking of the anatomical peculiarities of the rectum, the mucous membrane of the bowel is but loosely attached to the submucous tissue, so that prolapse very readily occurs. As the result of inflammatory processes and of straining at stool this connection may become still further loosened, so that the prolapse becomes more and more extensive. It is customary to distinguish between prolapse of the anal mucous membrane and prolapse of the rectum, in which the entire bowel may protrude through the anus, carrying with it, as already described, a pouch of peritoneum. Prolapse of the anus and rectum occurs much more frequently among children than among adults. The causes are, first, that the attachments of the rectum are much less firm in children; further, that the course of the bowel in infants is very nearly straight, instead of curved, as in adults, and that children are

much more in the habit of straining at stool violently, and are very prone to suffer from chronic diarrhea and rectal tenesmus, caused by the presence of catarrh or worms or other sources of irritation. During middle life prolapse of the rectum is rare except in those individuals who have lost their muscular tone, or who have become emaciated, or, as is the case with women who have borne many children, when the integrity of the muscular and ligamentous structures of the perineum has been destroyed by lacerations during labor. In old age, also, when all the tissues are relaxed, prolapse of the rectum is not uncommon. Any of the conditions which produce rectal tenesmus, such as hemorrhoids, acute catarrhal inflammation of the rectum, hypertrophy of the prostate, cystitis, stone in the bladder, inflammation of the posterior urethra, all predispose to prolapse of the rectum. The disease usually comes on, at least in adults, by degrees; in children, sometimes quite suddenly, as the result of straining at stool during acute diarrhea, etc. When it occurs gradually a small portion only of the mucous membrane protrudes at first, and is readily replaced. If the exciting cause continues, the prolapse becomes more and more marked as time goes on, until it may become very extensive indeed, and project through the anus a number of inches. When the prolapse occurs suddenly and the sphincter muscle remains intact, venous congestion and swelling of the bowel may occur, so that its replacement may be difficult or even impossible. In certain cases ulceration and even gangrene of the entire prolapsed portion of gut may occur, sometimes with death from general peritonitis or from septicemia.

FIG. 36.—PROLAPSE OF THE RECTUM.
(Collection of Dr. Charles L. Gibson.)

Diagnosis of Prolapse.—The diagnosis is entirely simple and can only be confounded with intussusception, the difference being that in prolapse of the anus and rectum the skin of the anal orifice passes directly on to the mucous membrane of the bowel, whereas in those cases of *intussusception* which protrude through the anus it is always possible *to introduce a finger or a probe*

between the prolapsed bowel and the anal margin. Upon inspection a sausage-shaped tumor is seen protruding from the anus covered by reddened and congested mucous membrane. If the prolapse has existed for some time or has become chronic the surface of the mucous membrane will be in a state of inflammation, sometimes of ulceration. In some cases the mucous membrane, if long exposed to the air, will have become thickened, toughened, and insensitive. At the apex of the sausage-shaped tumor will be found the orifice of the bowel. The condition when the prolapse is complete is always attended by incontinence of feces. In recent cases it is usually possible to reduce the prolapsed bowel by suitable manipulation. In chronic cases adhesions may have formed between the prolapsed peritoneal layers, such that reduction may be impossible. In the most severe cases, coils of small intestine may be included in the tumor, and these may be adherent. When this condition is present the tumor may be resonant upon percussion, and gurgling sounds may be produced by manipulation.

FIG. 37.—PROLAPSE OF THE RECTUM AND EXSTROPHY OF THE BLADDER. (New York Hospital, service of Dr. Frank Hartley.)

THE TUMORS OF THE ANUS AND OF THE RECTUM

The commonest form of benign tumor of the anus is papilloma, the so-called pointed condyloma or acuminate wart. The occurrence of these papillomata is nearly always due to the presence of some irritating discharge either from the vagina or from the rectum; in women from the irritation of the skin of the perineum, produced by gonorrhea, although other irritating discharges are capable of producing acuminate warts as well. Owing to this peculiar method of causation the disease is much more frequent in women than in men. Often in addition to the formation of these warts in the vicinity of the anus, the vulva and perineum will also be involved. The tumors are usually multiple, very rarely single. They spring from the cutaneous margin of the anus as minute threadlike, vascular, pink outgrowths, sometimes simple, sometimes branch-

ing. In some cases the tumors remain small, as large as the head of a match or as large as an almond. In other cases they may grow very large indeed, so that the entire anus is surrounded by a cauliflowerlike mass, which may be mistaken for cancer by the uninitiated. The base of a cancer of the anus is always hard and infiltrated. The base of the simple papillomata is soft. A cancer is always broadly sessile, the papillomata are frequently pedunculated. From their situation these tumors are kept moist by perspiration and other secretions; the epithelium covering the surface is in a state of rapid proliferation, and the surface is thus continually covered with a smeary, cheesy-looking, frequently foul-smelling discharge. The little tumors tend to multiply themselves indefinitely upon the surrounding skin, so that in some cases hundreds of them will be present of all sizes from minute papillary projections to masses as thick as two fingers. Their consistence is rather soft unless they have been inflamed; they are pinkish-white in color, and have a perfectly characteristic cauliflower appearance. As the result of local irritation or trauma they may undergo ulceration.

The other benign tumors of the anal region are rare; small, sebaceous cysts are occasionally seen, sometimes multiple and due to the retention of the contents of the numerous sebaceous follicles surrounding the anus. Sometimes as many as twenty or more of these little tumors may be present. They are recognizable at once upon inspection, resembling a giant comedo. As is the case upon the face, the orifice of the duct of the gland is frequently dilated, and its contents can be seen as a black point. Upon pressure yellow or white sebaceous matter is extruded. Minute cysts and fibromata occasionally occur around the border of the anus, sometimes having their origin in an external hemorrhoid.

Malignant Tumors of the Anus.—Epithelial cancer occurs at the margin of the anus as a comparatively rare disease, and is far less frequent than is cancer of the rectum proper. As in other situations, epithelioma of the anus occurs in two forms: the flat superficial epithelioma growing from squamous epithelium, and the more rapidly spreading type arising from the epithelium of the cutaneous glands. Chronic irritation seems to predispose to the disease—hemorrhoids, fissure, chronic eczema, and the like. The squamous-celled epithelioma of the anus appears to be of more rapid growth, more malignant, and more likely to infect early the inguinal lymph nodes than is the case upon the skin of the face. It presents itself at first as a flattened or papillary thickening of the skin, which breaks down and forms an ulcer with indurated borders and a hard base. The appearances do not differ, in other words, from similar cancers upon other parts of the body. (See Tumors.) The epitheliomata growing from the glandular structures of the skin begin as a nodular infiltration, which also soon breaks down into a crater-formed ulcer with indurated edges and base. Not infrequently papillary outgrowths of the cauliflower description sprout up from the ulcerated surface The disease tends to invade and to destroy the surrounding structures quite rapidly.

The sphincter muscle is frequently invaded and becomes incompetent, so that the patients suffer from incontinence of feces. The subjective symptom in both these forms is pain, notably when the disease has invaded the anal mucous membrane. Such pain may be very severe, and is made worse when the bowels move. The greatest suffering and inconvenience is caused by the loss of the sphincter muscle and the consequent incontinence of feces. The inguinal glands become enlarged quite early in the disease. They are readily recognized as firm, rounded tumors in the subcutaneous tissue of the groin. Epithelioma of the anus is one of the more malignant forms of cancer, and the prognosis is in general unfavorable.

Tumors of the Rectum Proper.—The tumors of the rectum may be divided into those arising from the connective tissues and those arising from the epithelium of the rectal mucous membrane. The connective-tissue tumors of the rectum are in general rare; lipoma, fibroma, myoma, myofibroma, and angioma have all been observed in a few cases. These tumors may be small, sessile, or pedunculated with the exception of the angioma, or they may attain a very considerable size. The diagnosis is to be made by the symptoms of pain and discomfort, or of obstruction of the rectum, or sometimes, if the tumor be small, its prolapse through the anus during defecation. A microscopic examination will be necessary to determine the exact character of the growth. As very rare conditions echinococcus has been observed in the rectum, and in a few cases dermoid cysts. Sarcoma has been observed in the rectum chiefly of the melanotic type. They have been sessile, or sometimes partly pedunculated tumors, and have reached the size of a fist or larger. In the later stages of the disease ulceration of the mucous membrane and hemorrhages have been observed. The prognosis of melanotic sarcoma of the rectum is as bad as is the case with melanotic sarcoma in other parts of the body. Metastatic tumors and infection of the regional lymph nodes occurs early. A very few successful cases of operation have been reported.

Epithelial Tumors of the Rectum.—Benign epithelial tumors of the rectum occur in several varieties. The commonest of these is the so-called mucous polypus. They proceed from localized hypertrophies of the mucous membrane and of its glands. Mucous polypi of the rectum are most often observed in children and young people. They usually grow from the mucous membrane in the lower part of the rectum, just above the internal sphincter, and usually from the posterior wall of the gut. They are usually solitary tumors, rarely multiple. They vary in size from that of a pea to nodules as large as the last joint of a man's thumb. At first sessile, they become after a time, from traction by the movements of the bowels, pedunculated tumors. In general appearance they suggest a strawberry or a raspberry. There may be no symptoms produced by these little tumors. Sometimes the surface of the growth becomes eroded or ulcerated, and may bleed. Frequently one's attention is first called to the condition by the fact that while straining at stool the tumor has protruded from the anus, and has been noticed by the child

or by its mother, or that, on the other hand, after having protruded, it can no longer be reduced. The diagnosis is made by digital examination and by the use of a tubular rectal speculum, as already described. The tumors are rather soft in consistence, and if sessile no infiltration or induration of the mucous membrane of the bowel is observable; if the tumors are multiple, they are sometimes associated with the symptoms of catarrh of the lower bowel. In advanced life such polypoid growths may undergo cancerous degeneration.

Diffuse Polypoid Hypertrophy of the Mucous Membrane of the Rectum.—This rare condition has been observed and reported in only a small number of cases. The disease has always been observed in young persons, and in the reported cases heredity seems to have played some part. The mucous membrane of the rectum, sometimes throughout its whole extent and sometimes the mucous membrane of the colon and the cecum as well, is the seat of multiple polypoid growths, varying in size from that of a pea to that of a plum, so thickly studded over the mucous membrane as to form a solid, uneven mulberry surface. The disease is associated with chronic catarrhal inflammation of the bowel and with hemorrhages, and in a large proportion of cases the result has been a fatal one in from two to ten years. The patients gradually become emaciated and exhausted from the continued loss of small quantities of blood. The symptoms consist of the discharge of mucus, pus, and blood from the bowel, of diarrhea, and of severe rectal pain and tenesmus. The diagnosis is to be made from the history and from the inspection of the bowel through a tubular speculum. In a certain proportion of cases the polypoid growths have become the seat of cancerous degeneration, and have thus destroyed life.

Villous Tumor of the Rectum.—Villous tumor of the rectum is a rare condition, which was studied and described by Virchow and Esmarch. Unlike the ordinary polypoid growths observed in the rectum, villous tumor occurs usually during advanced life, for the most part between the ages of forty and sixty years. They appear to be prone to undergo cancerous degeneration. The lesion consists of the formation in the mucous membrane of the rectum of single or multiple sessile or pedunculated tumors, soft in consistence, and of a reddish color, varying in size from that of a pea to that of a hen's egg, very rarely larger. The surface of the tumor is peculiar in that it is covered with delicate threadlike papillæ which give the growth a velvety surface. If the tumor is submerged in water the threadlike processes of mucous membrane float about loosely from the surface, as though the tumor were covered with a fine, soft growth of hair. The symptoms produced by villous tumor of the rectum resemble those caused by the ordinary mucous polypi, except that hemorrhage is more common and more severe. The condition is usually associated with chronic catarrhal inflammation of the lower bowel, producing its characteristic symptoms. If situated low down in the rectum the tumor may prolapse through the anus during straining at stool. It is important to differentiate these tumors from ordinary mucous polypi because

the former are quite prone to undergo cancerous degeneration. When villous tumor of the rectum is sessile it may often be mistaken for the softer forms of carcinoma.

Cancer of the Rectum.—A number of different forms of cancer occur in the rectum. By far the commonest form is, as one might expect from the origin of the growth in the mucous glands of the rectum, the cylinder-celled carcinoma. Another form of malignant growth occurs in the rectum possessing certain peculiarities, known as malignant adenoma of the rectum. Upon microscopic examination there is nothing to distinguish this latter form of tumor from a benign adenoma, although it possesses the peculiarity that it invades the entire wall of the bowel, and may grow into the surrounding tissues and produce metastatic tumors in other parts of the body. It is, however, a less frequent form of growth than the ordinary cylinder-celled cancer or adenocarcinoma, as it is called. In certain cases of adenocarcinoma of the rectum the tumor takes on a more rapid growth, and the cells cease to preserve the ordinary cylindrical type, become polygonal, ovoid, or round, and instead of a glandular structure arrange themselves in irregular alveoli. We then speak of alveolar carcinoma of the rectum. As in other situations, various types of cancer may occur, the distinction being chiefly the relative proportion of fibrous stroma and of cells to be found in the tumor; thus scirrhous and medullary forms of carcinoma are observed, representing respectively the harder and softer forms of cancerous tumor. As in other situations, cancer of the rectum begins as a nodular or more diffuse infiltration of the rectal wall, which tends to spread superficially and deeply and to infiltrate all the coats of the bowel, to ulcerate, to bleed, to undergo necrotic and putrefactive changes, to contract, thereby shortening the intestine in length, and by surrounding the gut to produce stenosis of the bowel of a more or less marked degree. Cancer of the rectum is nearly always a solitary tumor, or in very rare instances there may be more than one cancerous area present.

Classification of Cylinder-celled Carcinoma.—The cylinder-celled carcinoma, the most frequent form, is usually grouped into three principal types: First, adeno-carcinoma, occurring in the ampulla of the rectum, is a tumor which varies, according to the relative proportion of cells and stroma, from the medullary and soft to the scirrhous and hard form of the disease. It occurs most commonly in the lower portion of the rectum, two or three inches above the anus, most frequently on the anterior wall, less commonly upon the posterior wall, and rarely upon the lateral walls of the gut. A large proportion of these tumors sooner or later completely surround the bowel, producing stenosis. The second group belong to the scirrhous or fibrous form of the disease, and are situated high up in the rectum, sometimes as high as the sigmoid flexure of the colon. They begin as small, hard nodular tumors, which soon surround the bowel and produce a stricture. They are less frequent than the preceding form, and constitute about one third of the cases. In the third group are included the diffused forms of cancer of the bowel, which infiltrate

a very considerable part of the wall of the rectum from the start. Such carcinomata may be of the ordinary adenomatous type, or in some instances softer carcinoma. They usually begin in the lower part of the rectum and spread upward, involving all the coats of the bowel, converting it into a narrow rigid tube. By sloughing, the caliber of the bowel may again be increased, and the walls being hard and inelastic, the rectum is converted into a cavity with rigid, irregular walls, filled with putrid, broken-down cancerous material, pus, feces, and blood.

Very rarely it is possible for a cancer to arise from the remains of fetal structures, behind the rectum and in front of the coccyx, and only secondarily to invade the wall of the gut (Kraske). (See Spine.)

Cancer of the rectum invades the surrounding structures—bladder, prostate, etc.—only late in the disease, and, in case the patient survives, may form a massive tumor, occupying a considerable part of the pelvic cavity. The spread of cancer through the lymph channels was especially studied by Gerota, who distinguished four lymphatic territories: (1) The skin of the anus. (2) The intermediate zone of the anal portion of the rectum. (3) The columnar zone of the anal portion. (4) The pelvic portion of the rectum. Zones 3 and 4 correspond with the course and distribution of the superior hemorrhoidal arteries and veins; these extend to the lower limits of the columns of Morgagni. The lymph vessels of the intermediate zone anastomose freely with the lymph channels of the anal skin below and with those of the columnar zone above (Rotter). The lymph nodes of the groin receive, as stated, the lymph from the anal margin. There are several lymph nodes on either side of the rectum, lying in the loose fatty connective tissue between the insertion of the levator ani into the rectum and the reflection of the peritoneum, constituting the *cul-de-sac* of Douglas. They are arranged along the course of the superior hemorrhoidal vessels and lie beneath the so-called fascia propria of the bowel. Above the reflection of the peritoneum the glands come to lie behind the rectum and form a chain continued above in the mesentery of the sigmoid. The situation of these glands assumes a practical importance when we come to operate for the cure of cancer of the rectum, since they are usually infected, and should be carefully sought for and removed in every case. This is not true of the inguinal glands, if apparently normal, assuming that the cancer is well within the bowel.

Causation.—Cancer of the rectum occurs in the majority of instances without apparent cause. It may, as already stated, follow chronic disease of the mucous membrane, polypoid hypertrophy, villous polypus, piles, chronic ulceration of the bowel, and other conditions causing long-continued irritation, but such a causative relation is exceptional. It is, like other forms of cancer, a disease of middle age and of advanced life. About half the cases occur between the ages of fifty and sixty-five, and yet the disease appears in persons under thirty, perhaps more often than any other form of cancer, two to three per cent of the cases, and in young people runs a peculiarly rapid and fatal

urse. Allingham saw cancer of the rectum in youths of thirteen and seven-en years. The form of the disease in the young is nearly always the soft nfiltrating form of cancer (medullary cancer). The disease is more common mong men than among women, but not markedly so. An hereditary history of ancer of the bowel is traceable in about ten per cent of the cases.

Symptoms and Diagnosis of Cancer of the Rectum.—The characteristic symptoms of cancer of the rectum may be referred chiefly to two of the nearly constant phenomena of the disease—namely, ulceration of the tumor tissues and stenosis of the bowel. The beginning of the disease is ushered in by vague and indefinite symptoms rarely sufficiently marked to cause the patient to seek medical advice; such are a sense of fullness or dull pain referred to the sacral region during defecation. The characteristic symptoms commence when the surface of the tumor breaks down and ulcerates. They are the passage of mucus and blood with the stools, mixed with bits of necrotic tumor tissue; at first, if the caliber of the bowel is still free, the movements will simply be streaked with mucus and blood; later, bleeding will be more or less profuse, according to the character of the tumor. The amount of bleeding is often in an inverse ratio to the degree of stenosis—i. e., the softer, more rapidly growing cancers break down earlier and bleed more than the fibrous and scirrhous types. Marked symptoms of stenosis may long be wanting in the softer forms, whereas the fibrous cancers soon contract and produce symptoms of stenosis of the bowel, while they usually bleed but little. Still, the symptom of hemorrhage is more or less marked in nine tenths of all the cases.

As the disease progresses there are added the symptoms of catarrh of the rectum. The patients suffer from frequent or constant desire to stool, and the evacuations are small and attended by distressing pain and tenesmus. The stools consist of foul, horribly fetid material, consisting of mucus, pus, blood, broken-down putrid cancer tissue, mixed with fluid or semifluid feces. In the softer forms of cancer ulceration often proceeds rapidly and deeply, and hemorrhage from the bowel may occur frequently or constantly with every stool; the patients are thus rapidly reduced in flesh and strength and pass into the typical condition known as cancerous cachexia, a sallow, grayish-yellow pallor, a dull and apathetic, though often anxious, facial expression, muscular weakness, etc. In not a few cases the bleeding may reach alarming proportions, reducing the patient to a profound degree of anemia and prostration in a very short time. In the ulcerating forms absorption of the putrid contents of the bowel adds a chronic septicemia to the picture, the patients have an evening elevation of temperature, sweats, loss of appetite, headache, etc.

Symptoms due to *stenosis* of the bowel are most marked in the fibrous contracting forms of the disease, notably those situated high up in the rectum. In these cases the early symptoms are those of gradually increasing obstinate constipation; for a time these patients seek to overcome the difficulty by the use of purgatives; gradually there are added a sense of weight and fullness in the pelvis; straining at stool is accompanied by pain and tenesmus; bleeding

is usually slight; the constipation becomes more and more marked; the colon is distended with accumulated feces. *In some cases a peculiar and distressing form of diarrhea ensues.* Small quantities of feces mixed with mucus and pus are continually finding their way through the stricture, and, entering the lower rectum, cause a frequent painful and distressing desire to stool; such movements may be repeated every half hour or oftener, day and night; the sphincter becomes relaxed, sometimes paralyzed; there may be incontinence of feces. The constant straining may cause the cancerous ring to be invaginated into the lower rectum, producing a kind of intussusception with an increase of the painful and obstructive symptoms. In the softer forms of cancer obstructive symptoms also are rarely wanting, though extensive sloughing of the growth may cause them to be less marked or even intermittent. In the fibrous cancers the stricture may become so narrow that symptoms of intestinal obstruction occur. Involvement of surrounding structures, notably the bladder and prostate, cause the symptoms of frequent and painful urination and constant vesical tenesmus; later of putrid cystitis. Perforation into the general cavity of the peritoneum causes fatal peritoneal sepsis. Although, as stated, the early symptoms of cancer of the rectum are not very marked nor definite, there is no sadder or more distressing picture than is presented by advanced cases of this disease, unrelieved by surgical means. The constant pain, loss of sleep, weakness from hemorrhage, chronic sepsis, the patient dying, in fact, by inches, forms a combination dreadful to contemplate. The duration of life in unoperated cases varies a good deal in the different forms of the disease. In old people with the scirrhous type of cancer life may be prolonged four or five years. In young people with medullary cancer or other diffuse infiltrating type the duration of life is much shorter, and varies from eight months from the beginning of noticeable symptoms to two years in the less rapid cases.

The *diagnosis* of cancer of the rectum is in most cases very easy, provided the tumor is within reach of the finger or can be seen through a tubular speculum. The bleeding, sloughing, and putrid decomposition of the contents of the bowel are striking and characteristic signs. It is perhaps hardly necessary to state in this place that it is the duty of the medical practitioner as well as the surgeon to make a digital and, in case of any doubt, an ocular inspection of the rectum, *when patients complain of pain, of bleeding, of obstinate constipation, etc., or in any case pointing to serious disturbance in the rectum.* A diagnosis, made from the statements of the patient, of piles, diarrhea, constipation, and the like, and treated by local or general medication applied by him, is a careless and unjustifiable procedure. Cancer of the rectum is only curable by operation very early in the disease. The diagnosis must therefore be made, and treatment applied, if at all, at the earliest possible moment, if it is to be curative. It cannot be too strongly impressed upon the practitioner of medicine that the time to operate on cancer, wherever situated, is while the patient is still in good general health.

The *local signs* on palpation vary. In the cases which do not as yet surround the rectal tube the finger comes upon an ulcerated surface, usually rather deep and irregular, with a hard base, and hard, elevated, irregularly scalloped edges. Such an ulcer may be round, elliptical, or irregular in shape. The sensation perceived by the finger is very different from that produced by ordinary ulceration, whether simple or tubercular, in which the base and borders of the ulcer are soft, and differs again from the firm, smooth, cicatricial funnel-shaped obstruction felt in cases of stricture of the rectum following syphilis or other chronic forms of inflammation. In cases of cancer the mucous membrane of the unaffected portion of intestine feels normal up to the border of the tumor; in syphilitic ulceration the induration is widespread and diffuse. When the cancer entirely surrounds the gut, the edges of the ulcerated area are again hard, but fissured, knobby, and irregular. The softer forms of carcinoma give the impression of nodular, soft, even spongy tumors with ulcerated surfaces, usually large in extent, bleeding freely, and palpable, widespread infiltration of the wall of the bowel, much less firm and rigid than is the case with cicatricial stricture. Inspection of the rectum through a tubular speculum usually enables one, from the characteristic sloughing, putrid, bleeding surface of cancer, to distinguish it instantly from stricture arising from a chronic inflammatory process. When the cancer is of the fibrous type and is situated high up in the rectum, invagination of the cancerous ring into the lower portion of the bowel may occur, and may lead to a temporary difficulty in diagnosis. In the high-placed cancers of the rectum the portion of the bowel below is usually relaxed, dilated, and filled with gas or with the materials already described. Hochenegg called attention to this sign as being characteristic. When the cancer cannot be reached with the finger, the patient is put in the knee-chest position and examined with the proctoscope or sigmoidoscope, as the case may be; if necessary, under a general anesthetic. In cases of doubt a small portion of tissue may be pinched off or excised with a long pair of scissors and subjected to microscopic examination, solving the question of diagnosis at once. In cases of cancer of the rectum it is unwise to pass bougies or other instruments into the bowel, for fear of injuring or perforating the diseased wall of the gut. The presence of bleeding and the discharge of putrid material from the rectum will usually give a hint as to the diagnosis, so that this error is not very likely to be made. The oft-quoted symptom of tapelike stools has no real diagnostic value in cancer of the rectum. The possible diagnostic value of injections of water into the bowel in cases of tight stricture has already been mentioned. The differential diagnosis from sarcoma of the rectum is usually not difficult. The sarcomata form massive tumors which rarely completely surround the bowel. They are during their early stages covered with mucous membrane, though later on ulceration and serious hemorrhage is prone to occur. In cases of doubt excision of a small portion of the tumor will establish the diagnosis.

CHAPTER IX

HERNIA

General Remarks.—By the word hernia we mean the protrusion of any organ from the cavity within which it normally lies. In the present chapter I shall consider merely the protrusions of the abdominal viscera through the abdominal wall. When a portion of the abdominal contents escapes through an accidental wound we ordinarily characterize the condition not as a hernia, but as a prolapse or merely as a protrusion. We have already spoken of the various forms of internal herniæ, and in this chapter I shall confine myself to describing the diagnosis of the external protrusions. Herniæ, in general, may be divided into those which are congenital or acquired. By congenital hernia we mean the protrusion of any of the abdominal viscera through an opening which normally patent during fetal life has failed to close as it should before birth. By an acquired hernia we mean a protrusion which occurs at one of the points in the wall of the belly, which, owing to its formation, is naturally weak. Such relatively weak points in the abdominal wall occur in a variety of situations. Thus there may be mentioned the inguinal canal, the femoral canal, the umbilicus, the linea alba, the outer edge of the rectus muscle, the obturator foramen, and still other forms, most of them quite rare, such as the perineum, hernia through the pelvic floor, pudendal, lumbar, ischiatic. For a proper understanding of the different varieties of hernia it is necessary to describe somewhat in detail the essential parts constituting a hernial protrusion. They are the hernial orifice, the hernial sac, and the contents of the sac.

1. *The Hernial Orifice.*—Although a protrusion of the abdominal viscera may occur at any point in the abdominal wall, yet certain situations are far more common than others. These situations may be divided into two groups: First, places where the strength of the abdominal wall is diminished by the passage of blood-vessels or of other structures, such as the spermatic cord and testis in the male and the round ligament in the female, from the abdominal cavity outward. Other similar places are the crural ring, the obturator foramen, the umbilicus, the ischiatic notch. In the second group belong those places in the abdominal wall where spaces exist between muscular or fascial layers, such that the resistance of the abdominal wall is weakened; among such places may be mentioned the lumbar region, the linea alba, the pelvic floor, and the outer border of the rectus abdominis.

2. *The Hernial Sac.*—An essential part of every hernia consists of a protrusion through the abdominal wall of a pouch of parietal peritoneum. Such pouches are formed by pressure from within, and the size of the sac may be subsequently increased by traction from without and by its general distention by the addition of new portions of the abdominal contents. The shape of the sac of peritoneum varies in the different types of hernia and in different stages of the condition. In the ordinary forms of oblique inguinal hernia the sac is at first funnel-shaped, later it becomes elongated and cylindrical; as the sac increases in size and descends into the scrotum it becomes pear-shaped. In the direct form of inguinal hernia the sac is usually spherical or nearly so. The same is true of umbilical hernia. That part of the sac situated at the hernial orifice is usually its narrowest point, and is known as the neck. In oblique inguinal hernia the neck is usually situated at the internal abdominal ring; in femoral hernia at the inner orifice of the crural canal. As the sac increases in size it may become more or less irregular in shape. Secondary protrusions may occur from the sac itself. Such are known as diverticula of the sac. Not infrequently the sac becomes contracted at one or more points, so that two or more considerable cavities may be formed, joined by relatively narrow orifices. This is often due to the fact that as the hernia increases in size the parietal peritoneum is dragged or pushed farther and farther outside the abdominal cavity, so that the part originally constituting the neck comes to lie outside the abdomen and remains narrow, and such progression of the sac may be repeated more than once, each narrow place corresponding to what was formerly the neck. The other parts of the sac are known as the mouth, which may or may not correspond with the neck of the sac and the fundus or body. In certain forms of hernia, notably in hernia of the cecum and urinary bladder and in some other forms to be mentioned, the sac is imperfect or deficient.

Congenital Form of Inguinal Hernia.—In the congenital form of inguinal hernia the sac consists of the original (processus vaginalis) funicular process of peritoneum which descended with the testis and has failed to close. In this form of sac the hernial contents lie in immediate contact with the testis. In recent hernia the lining of the sac consists of normal, smooth, glistening peritoneum. As time goes on changes of one sort or another may occur, due to irritation from the pressure of a truss, to inflammation, and other causes to be described, such that the sac becomes thickened, roughened, loses its smooth and glistening character, and comes to resemble, more or less, scar tissue. In ancient hernia hemorrhages may occur in the wall of the sac and calcareous plaques are occasionally observed. As the result of inflammation the walls of the sac may become more or less completely adherent and its cavity obliterated, producing a natural cure of the hernia. In other cases the sac will be only partly occluded, and thus there may be formed an empty pouch of peritoneum no longer connected with the interior of the belly or filled with serous fluid. This condition is known as hydrocele of the hernial sac when due to the partial

congenital obliteration of the funicular process, as hydrocele of the cord, c sometimes as encysted hydrocele. Occasionally tuberculous or cancerous degen eration may occur in the interior of the sac. In many old cases of hernia notably in umbilical hernia, and in large inguinal hernia, adhesions form between the wall of the sac and its contents, so that the viscera in the sa can no longer be replaced in the abdomen. Such adhesions may become very firm indeed, so that they can only be separated, if at all, by a careful dissec tion. The only condition under which a hernia possesses no true peritoneal sac are when, for any reason, such as inflammation, or sloughing, or an oper ation, the peritoneum is destroyed and the abdominal contents protrude, being simply covered with scar tissue. As already mentioned, in some forms of hernia the sac may be incomplete. This occurs when viscera like the cecum or the bladder, only partly covered by peritoneum, are pushed or dragged into a hernia. In these cases the relations of the peritoneum to the protruded viscera remain practically the same as one finds within the abdominal cavity. Thus in hernia of the cecum the sac is incomplete posteriorly, so that it would be possible to cut down upon the intestine in such a case without opening the peritoneum. The same may be true of the urinary bladder or of the ascending or descending colon. It is to be borne in mind that when the funicular proc ess of peritoneum or the canal of Nuck remains patent after birth in the male and female respectively, a sac may exist in the scrotum or labium communi cating with the interior of the belly, but containing no abdominal viscus. When any of the abdominal viscera enter such a canal the condition is known as congenital hernia, but such a prolapse may not occur for many years. In other words, the term congenital hernia does not mean that the individual is necessarily born with a hernia, but only that the hernial sac is congenital, and that the hernia itself may not occur until adult life.

3. *Contents of the Sac.*—Any and every abdominal organ may protrude into a hernial sac. The pancreas has, however, only been found in one or two cases of large umbilical hernia, and never in any other situation. The most frequent structures which enter the sacs of all herniæ are the *intestine* and the *omentum*. The small intestine more often than the large, the sigmoid flexure often, rarely the cecum; in the umbilical variety the transverse colon. In inguinal and femoral hernia occasionally the urinary bladder or the ovaries When the sac contains intestine alone it is known as an enterocele; when i contains omentum, as an epiplocele; when both are present, as entero-epiplocele The intestine alone occurs about twice as often as the omentum alone in ingu nal hernia. In the femoral variety the intestine alone is found about five times as often as omentum alone. In umbilical hernia of adults both intestin and omentum are usually present. As might be expected from its greate mobility, the small intestine in its lower fourth being the most movable pa of the alimentary canal, is more apt to protrude than any other portion. I large and ancient hernia several coils of intestine may be present; often combination of large and small intestine with omentum. The portions of larg

intestine most often found are the transverse colon and the sigmoid flexure. Certain unusual and peculiar forms of hernia deserve mention. When Meckel's diverticulum is found in a hernia, the condition is known by the name of the man who first described this form of protrusion, Littre (Littre's hernia). Another peculiar form of hernia, important from a diagnostic point of view, is known as partial hernia (Richter's hernia). By this term we mean that only a part of the intestinal wall enters the hernial sac, usually that side farthest away from the mesentery. We shall speak more particularly of this type of hernia when discussing the signs and symptoms of strangulated hernia. Occasionally the vermiform appendix is found in a hernial sac, sometimes alone, sometimes together with a portion of the cecum. An appendicitis may occur in such a hernial sac, and would usually lead to a confusion of diagnosis. The stomach is sometimes found in large umbilical herniæ, much more rarely in inguinal herniæ; and in a few cases of the small epigastric herniæ occurring in the linea alba, a small pouch of stomach has been found in the hernial sac. This is denied by some observers. The omentum is, next to the small intestine, the most frequent structure found in herniæ. Its prolapse is very common in adults and very rare in infants, because in the latter the omentum is relatively short. A prolonged residence in a hernial sac usually produces marked physical changes in the omentum; it becomes tough, knobby, thickened, contains a greatly increased amount of connective tissue, and often forms adhesions to the sac and to the intestine or other viscus, if such be present. The urinary bladder is found in inguinal, more rarely in femoral herniæ (four to one), very rarely in any other type. Frequently during radical operations for the cure of inguinal hernia while making strong traction upon the hernial sac; the bladder, covered by fat; that is, its extraperitoneal part appears in the wound. It is a point of great practical consequence to recognize this structure as the bladder, since otherwise it might be included in the suture or ligature applied to the neck of the sac or even incised. This accident has happened even to good and careful surgeons, and if unrecognized will almost inevitably produce a fatal result. *If, when about to suture or tie the sac, a mass of fat appears at the inner side of the neck, it should be gently pushed back into the abdomen and let alone.* If it seems desirable to identify such a mass, the bladder may be recognized by gently separating the fatty tissue, which discloses the muscular ridges of the bladder wall, together with abundant blood-vessels ramifying on its surface. True hernia of the bladder, either its intraperitoneal or extraperitoneal portion, occasionally occurs, notably in rather large inguinal herniæ. Three varieties are described: (1) Extraperitoneal, in which the bladder protrudes alongside of the sac of an ordinary hernia, or without any sac. (2) In which the bladder, covered by peritoneum, forms a part of or the sole contents of the sac. (3) Paraperitoneal, in which a part only of the bladder wall is covered by the peritoneum of the sac. The female genital organs, the ovaries, the tubes, and the uterus are somewhat rarely found in herniæ. The ovary more often than the other organs, and in most cases the

hernia, is congenital. When such is the case the ovary is irreducible. Such ovaries are, as is the case with misplaced testes, quite prone to undergo degeneration of one sort or another; sometimes cystic, sometimes cancerous. In the cases of congenital hernia of the ovary the peritoneal pouch always remains open into the abdominal cavity, and probably in a certain number of cases the ovary returns of itself into the abdomen during the early years of life. Hernia of the Fallopian tube and uterus occurs usually in the acquired form of hernia along with the ovary; very rarely is the tube found alone. When ovary, tube, and uterus occur in herniæ the intestine is also sometimes present. The normal uterus has in rare instances been found in a femoral hernia. The presence of the other abdominal viscera in a hernial sac is extremely rare. The liver is more apt to occur as a part of a diaphragmatic herniæ than in any other form, although it has rarely been observed in congenital umbilical herniæ in infants. A misplaced testis has occasionally been observed in a femoral hernia. (For a description of the so-called fat hernia occurring in the epigastric region, see Diseases of the Abdominal Wall.)

The external coverings of the hernial sac vary with the anatomical situation of the hernia. In some cases, notably of umbilical and femoral herniæ, they consist simply of the skin, with a greater or less quantity of subcutaneous fat. In other situations the coverings will consist of a number of layers of fascia, of aponeurotic structures, sometimes of muscles. The more recent the hernia the more likely it is to be covered by numerous anatomical structures. The recognition of all the layers forming the coverings of a hernia is of more anatomical than surgical interest. Often many of them are so thinned out by pressure as to be quite unrecognizable, the hernial sac may be directly adherent to the skin; in other cases they are thickened and cemented together by inflammatory infiltration into a homogeneous mass.

Occurrence and Causation.—An hereditary predisposition to hernia can be traced in about twenty-five per cent of the cases (Macready). Hernia is much more common in males than in females. Thus, Bull and Coley found in studying 33,600 cases of hernia treated in the Hospital for Ruptured and Crippled in New York City the following proportions: Inguinal hernia, male to female 6 to 1; femoral, male to female 1 to 2.14; umbilical, male to female 1 to 1.6. Of 22,751 cases of inguinal hernia, 5,554, or 25 per cent., were in children under fourteen years of age; while of 1,381 cases of femoral hernia only 18 occurred under the age of fourteen years. Generally speaking, the greater number of cases occur during the active period of life—i. e., between fifteen and fifty. Hernia is more common among males than females, largely on account of the fact that men lead more active lives, and that their occupations and habits entail more violent muscular efforts.

Direct Causes.—Sudden muscular strain, especially lifting, is the actual cause of hernia in a large proportion of cases; further may be mentioned coughing, sneezing, parturition. Conditions producing distention and weakness of the abdominal wall, pregnancy, obesity, ascites. Further, direct trauma

whether accidental or the result of surgical operations, so that the normal muscular layers are replaced by scar tissue; also paralysis and atrophy of the muscles of the belly wall due to the same causes. Finally, atrophic changes produced by old age or wasting diseases.

Diagnosis of Hernia in General.—While in the majority of instances the diagnosis of hernia is entirely simple, and may often be made correctly at sight, yet exceptions to this rule are by no means uncommon, and there are cases in which the diagnostic skill of the surgeon is tested to the utmost in differentiating hernia from certain other conditions. If a swelling exists somewhere upon the abdominal wall at one of the ordinary sites of hernia, which can be replaced into the interior of the belly, and especially if the contents of such a swelling can be recognized as belonging normally in the interior of the abdomen, intestine, for example, the diagnosis of hernia is plain. After such a swelling has disappeared in the belly it is usually possible by invaginating the skin with the finger to follow the track through which the hernia disappeared, and to determine its direction, its size, its length, and the dimensions of the so-called hernial ring. If, now, with the finger on the hernial aperture, the patient is requested to cough, to stand erect, to increase intra-abdominal pressure by contracting the muscles of the abdominal wall, it is usually possible to feel a distinct impulse, the effort made by the abdominal contents to escape again into the hernial sac, and if the pressure of the finger is gradually reduced, it is often possible to feel the intestine or omentum, follow it through the hernial ring, and again occupy the hernial sac. After the contents of the hernia are reduced, it is sometimes possible, by grasping the sac with the fingers, to derive the sensation of the peritoneal surfaces, rubbing one against the other.

In case the hernia cannot be replaced in the abdomen, we attempt by palpation of the region to follow the tumor up to and even through the abdominal wall, and thus to determine its actual connection with the interior of the abdominal cavity. We also seek to observe changes in the volume of the tumor. When the patient stands erect or coughs or strains, the tension of a hernia, if not strangulated, is usually markedly increased, as determined by palpation. If the patient again assumes a recumbent position the tumor frequently diminishes in size, and its tension is notably less. Further, an irreducible hernia is usually larger at night than in the morning, and is sometimes increased in size some hours after the ingestion of a full meal. It is sometimes possible to recognize the character of the contents of a hernia. As stated, the structures most frequently found are intestine and omentum. Intestine forms a smooth, rounded, elastic swelling of soft consistence, the sensation of tension is increased by coughing, by the erect posture, and during digestion. In large irreducible hernia with a thin sac it is sometimes possible to see peristaltic movements. These may occur spontaneously or as the result of cutaneous irritation. If, as is ordinarily the case, the intestine contains gas, it gives a tympanitic note on percussion; but flatness on percussion does not

exclude the presence of intestine, since the intestine may be empty, or, on the other hand, may contain merely fluid or solid contents and no gas. This is especially true of hernia of the large intestine. Moreover, the intestine may be so covered by omentum, or the coverings of the sac may be so thick that a tympanitic note is either absent or difficult to obtain. In distinguishing between fluid and intestine the light test is sometimes useful, notably in adults. (See Diagnosis of Hydrocele.) It is to be borne in mind that the intestine of children may be so translucent that the light is transmitted through it in the same way or to the same degree as is the case with fluid, and in this manner it is possible for a careless observer to be deceived.

A very important diagnostic sign in the examination of the intestine is the recognition of the mixed, fluid, and gaseous contents of the bowel from the gurgling sounds and sensations that are transmitted to the examining hand as the intestine is replaced in the abdominal cavity, or even upon manipulation without such replacement. The omentum is recognized on palpation as a rather soft, elastic, lobulated structure, suggesting the physical signs of a soft lipoma; the rounded elastic feeling of intestine is wanting, there is flatness on percussion, the impulse on coughing is less marked than is the case with the intestine, and usually reduction is accomplished with more difficulty. If the omentum has long occupied the hernial sac and has been inflamed it frequently feels knobby and hard, and under these conditions the dependent portion of omentum is so increased in size that, though no adhesions are present, it can no longer be replaced through the narrow hernial ring. If the reduction succeeds it is not accompanied by gurgling; the upper portion of omentum nearest the ring must be reduced first, and the last portion to return into the abdomen usually goes back only after somewhat careful manipulation. If intestine and omentum both occupy the sac, and reduction is attempted, the intestine always goes back first. The recognition of other structures in a hernial sac is often difficult, sometimes impossible. Hernia of the ovary into the labium of a little girl may sometimes be recognized as an oval, firm elastic tumor, which is rarely reducible into the abdominal cavity. Pressure upon the ovary sometimes causes a feeling of nausea. By vaginal and rectal examination it is sometimes possible to push the uterus backward, and thus make traction upon the ovary, so that it is pulled toward the abdominal cavity, and thus its connection with the uterus may be demonstrated. In adult females a herniated ovary may increase in size and become more tender during menstruation, although this sign is not always present. Hernia of the urinary bladder cannot be recognized unless a large portion of the bladder is in the hernial sac. Under these conditions a narrow isthmus may form between the intra- and extra-abdominal portion of the bladder, and urinary disturbances may be produced. The hernial tumor will increase in size when the patient has not emptied his bladder for a number of hours, and will diminish after urination. Sometimes these patients find it necessary to empty the herniated portion of the bladder mechanically by external pressure with the hand; sometimes they

accomplish their urination in two stages: emptying the normally placed portion of the bladder first, and then changing their position to empty the herniated part. Sometimes they complain of painful, difficult, or frequent urination. A cystoscopic examination may clear up the diagnosis in some cases. When we meet with the bladder during an operation for hernia it may also be identified by the introduction of a steel sound through the urethra.

Influence of Hernia upon the General Health.—Many individuals go about with a hernia of considerable size and quite ignorant that the condition exists, unless one of the complications of hernia occurs. It is possible for a very large portion of the intestine to lie outside of the abdomen in a hernial sac—so large a proportion indeed that there is no longer room for it inside the abdominal cavity, and yet the individual may suffer from no symptoms other than from the mechanical inconvenience of the large tumor. In most cases, however, certain symptoms are produced, sooner or later, which call the attention of the patient to the abnormal condition. In more than ninety per cent of the cases there is pain. If the hernia has followed a sudden violent muscular strain, the patient may have had a sudden sharp pain, referred to the lower part of the abdomen or to the seat of the hernia, followed by a sense of weakness or of something having given way. An actual hernial protrusion, however, is usually not recognizable for some time, perhaps for weeks or months. The patient will suffer meanwhile from a sense of fullness or weakness at the seat of the hernia, accompanied by dull, dragging pain, increased by prolonged standing or straining, and caused to diminish or disappear when the patient lies down. In addition there may be intestinal disturbances, constipation, occasional nausea, and vomiting. A good many of these patients soon discover that the pain and discomfort is diminished by pressing over the site of the hernia with the palm of the hand. If the hernia becomes of considerable size and is not retained by a proper truss, the patients usually suffer from mechanical interference with the peristaltic action of the intestine, from constipation, sometimes from diarrhea, colicky pain, flatulence, dyspepsia, and other digestive disturbances. Under these conditions they are apt to become mentally depressed, to think much about the movements of their bowels, and to be disinclined for physical labor or exertion.

Clinical Varieties of Hernia.—The basis of the clinical classification of hernia depends upon the contents of the sac and the relations of these contents to the sac itself. There may be distinguished: (1) Reducible; (2) irreducible; (3) inflamed; (4) obstructed; (5) strangulated herniæ.

1. Reducible Hernia.—This is the most common variety, and includes all the herniæ in which the contents can be replaced into the abdominal cavity by ordinary means, such as posture and manipulation. As already stated, the earliest subjective symptom is pain, and the other symptoms will be such as have already been mentioned in the preceding paragraph. If the hernia is of the congenital variety, no pain may be associated with its production.

Objective Symptoms.—These depend largely upon the size of the hernia and the contents of the sac. If the hernia happens to be of the ordinary inguinal variety a tumor is only present when the patient stands up or coughs, and such a tumor may be simply a feeling of fullness appreciable on palpation in the inguinal canal. The tumor disappears spontaneously when the patient lies down. When the hernia has emerged from the external abdominal ring, and has passed into the scrotum or labium respectively, the physical signs will vary, as already described, according to the contents of the sac. The impulse on coughing and the gurgling sound when the intestine is reduced remain the characteristic signs of enterocele. Large scrotal herniæ, even though not adherent, cease to be spontaneously reducible. Often these patients may learn to replace the hernia in the recumbent position quickly and skillfully. The diagnosis of the variety and special forms and the differential diagnosis are discussed in the section on Special Forms of Hernia.

2. Irreducible Hernia.—A hernia is irreducible when its contents cannot be entirely replaced in the abdominal cavity, though the function and nutrition of such contents remain practically normal. The sac itself is only reducible in very recent herniæ; in congenital hernia, never. The commonest cause of irreducibility is the formation of adhesions between sac and contents, most often omentum. Further, adhesions between the contents, intestine to intestine or to omentum, such that the adherent mass is too large to pass through the ring. Inflammatory thickening of omentum, as already indicated, is a frequent cause. Further, when the sac is incomplete, so that the contents form a part of the wall of the sac, hernia of the cecum, for example. Also, when so large a portion of the abdominal contents have been habitually carried outside the belly that the abdominal cavity is no longer large enough to contain them. Irreducibility is most frequent in umbilical hernia, and is more common in the femoral than in the inguinal form, though any form may become irreducible. It occurs most often during middle life, and is comparatively rare among children. Ninety per cent of the cases contain omentum (Macready). Berger found omental adhesions or changes responsible for irreducibility in 318 out of 582 cases. The condition may be temporary or permanent, though a hernia long irreducible may finally become reducible. In congenital inguinal hernia of the cecum in children, the cecum, or in some cases other coils are found adherent to the testis, and thus irreducible.

Symptoms.—If the hernia is small, and consists merely of omentum, no subjective symptoms may occur. If large, dragging of the omentum upon the colon may produce more or less pain, discomfort, and disturbances of the functions of the bowel. Attacks of inflammation often occur in these cases. If the intestine is also irreducible, the condition is more serious, colicky pain, flatulence, and constipation are common. Obstruction or strangulation may take place at any time. These conditions occur more often in herniæ with a small hernial ring than in those where the abdominal walls are relaxed and flabby and the hernial orifice large. Irreducible hernia is a condition demand-

g operation, much more often than the reducible form. This is true of both guinal and femoral herniæ. Contraindications are, a very large hernia, treme old age, obesity, conditions contraindicating surgical operations in general. (See also Umbilical Hernia.)

3. Inflamed Hernia.—A localized peritonitis of the sac and its contents may occur in any hernia. It is most common in irreducible umbilical and femoral herniæ. The causes are accidental injury, the undue pressure of a truss, unduly prolonged or violent efforts at reduction (taxis), obstruction or strangulation of the bowel, or acute enteritis. The peritonitis is usually of the sero-fibrinous type. A considerable serous exudate may form in the hernial sac, and if the process ends in resolution new and firmer adhesions are formed. (See also Obstruction and Strangulation.)

Symptoms.—The hernia increases in size, becomes tender, hot, and painful. If much fluid is thrown out into the sac, fluctuation or semifluctuation may be detected. If omentum alone is present, it feels hard and knobby. There is usually a slight rise of temperature, 100° to 100.5° F., some acceleration of the pulse-rate. If bowel is in the sac, there is often nausea, vomiting, and constipation. If omentum merely, the symptoms are apt to be less severe, and to subside in a few days under rest and suitable local treatment. If the hernia contains intestine, and notably if it be large, the greatest watchfulness is necessary, since obstruction and strangulation are likely to occur. No cathartics should be given, only enemata to relieve obstructive symptoms.

Tuberculosis in a hernial sac has been observed, nearly always as a part of a tuberculous peritonitis within the belly.

Actual suppuration in a hernial sac, aside from strangulation, perforation of the intestine from typhoid or tuberculous ulceration, is occasionally observed from the spread of a localized or diffuse purulent peritonitis. Very rarely a hernia containing omentum merely becomes inflamed, and suppurates without any evident source of pyogenic germs. Appendicitis in a hernial sac has occasionally been observed. A definite diagnosis is hardly possible before operation. The following symptoms might lead to a suspicion of the condition. Sudden violent signs of inflammation in a right-sided inguinal hernia, which had been irreducible, and might well be small in size, vomiting, abdominal pain, and the rapid development of marked septic symptoms, without at first absolute obstruction of the bowels. In strangulated hernia, obstructive symptoms occur first; septic symptoms may appear later.

4. Obstructed Hernia—Incarcerated Hernia.—Impaction of solid feces in a coil of intestine occupying a hernia; usually large gut, may lead to obstruction, total or partial, without serious impairment of the nutrition of the intestinal wall. The condition is most often seen in old people with umbilical herniæ containing large intestine, or who have large inguinal herniæ containing sigmoid or cecum. The causes are constipation, indiscretions in diet (gluttony), and the neglect of proper precautions to keep the bowels open,

the condition being encouraged by the intestinal atony common in the elderly and in all coils of gut long resident in a hernial sac.

Symptoms.—The symptoms of obstructed hernia are characterized by a *gradual* onset. They are increased local discomfort and a sense of tension in the hernia, constipation, loss of appetite, a coated tongue, a foul breath, headache, sometimes nausea and *occasional*, not continuous, vomiting. Fever is absent. To these may be added colicky pain not only in the hernia, but in the abdomen. Locally the hernia will be found increased in size, but only moderately tender. Impulse on coughing is usually preserved, notably near the neck of the sac. It may be faint, or in the obese hard to detect. On palpation the doughy or hard scybalous masses may be more or less distinctly palpable. The tumor may be dull or flat on percussion or tympanitic in places, according to the presence or absence of gas in the bowel. If unrelieved, the condition slowly passes from bad to worse, the patients become weak from want of nourishment, they vomit from time to time, and toward the end the vomit may acquire a stercoraceous character, and they may die exhausted, from chronic intestinal obstruction and autointoxication, at the end of several weeks. In other cases strangulation may supervene; this is exceptional. After death no inflammatory lesion or serious impairment of nutrition may be found in the obstructed bowel. The treatment consists of high enemata, massage of the hernia and of the abdomen, washing out the stomach, but no purgatives until the bowel has at least been partly emptied. If, as is unusual, the hernia was reducible before the obstructive symptoms occurred, a careful and gentle effort may be made to empty and replace the hernia under a general anesthetic. Symptoms pointing to strangulation demand operation. The diagnosis is usually easy from the history of a large irreducible hernia, usually in an old person, the constipation, and the gradual onset of the symptoms, together with the physical signs, as described. The age of these patients and the character of these herniæ makes operative interference a serious matter.

5. Strangulated Hernia.—The importance of strangulated hernia relates usually to the presence of bowel in the sac, rarely to omentum alone. A hernia containing bowel is said to be strangulated when the lumen of the gut is occluded while the circulation of blood is cut off. The hernia becomes irreducible spontaneously, and gangrene of the bowel finally results.

Occurrence.—Strangulated hernia is rare during infancy, common during middle life and old age. It occurs more often in small herniæ with a narrow ring. More rarely in large herniæ with a large ring. More commonly in ancient than in recent ruptures, although a hernia may become strangulated at once as soon as it appears. It is more common in femoral than in inguinal hernia; 9.02 per cent of the cases in femoral, 2.16 per cent in inguinal (Berger's statistics). Ancient umbilical herniæ with prolapsed omentum and intestine and numerous adhesions often become strangulated.

Causes.—Muscular effort, lifting, coughing, straining, anything which causes a sudden increase of abdominal pressure, may lead to strangulation.

Certain diseases will therefore predispose to strangulation, constipation, a chronic bronchitis, stricture of the urethra, prostatic hypertrophy, and occupations involving violent muscular strains, especially lifting efforts.

Mechanism.—Much time and ingenuity have been expended in attempting to account for the occurrence of strangulation. Probably the mechanism varies much in different cases. The following factors have been considered important by different observers in the production of strangulation: (1) Elasticity of the ring (Richter). (2) Compression of the efferent by the distended afferent portion of the loop (Lossen). (3) Angulation of the distal end of the loop at the margin of the ring (Scarpa). (4) Fecal impaction. (5) Torsion or volvulus of the loop (De Roubaix). (6) Valvular folding of the mucous membrane (Roux). (7) Interposition of the mesentery between the limbs of the prolapsed loop, thus wedging the bowel more firmly against the borders of the constricting ring (Lossen). By whatever mechanical means the imprisonment and pressure upon the bowel is commenced, once started, the condition tends to continue and to grow worse, producing marked interference with the circulation of the bowel and of its mesentery; the mesentery becomes swollen, and is put upon the stretch by the violent peristaltic efforts of the intestine to free itself, and the disturbances of circulation may involve also the mesentery lying within the belly by obliteration of the lumen of its vessels by traction. Volvulus of coils of bowel lying within the abdomen may also occur. The *pathological changes* in the imprisoned loop are venous congestion, swelling and edema, paralysis of the muscular wall of the gut, an increased secretion of mucus in its lumen, hemorrhages into the wall of bowel and into its interior; at the same time a serous exudate, varying in amount, takes place into the sac from the bowel.

In large herniæ and also in cases where the strangulation takes place rather slowly, the quantity of serum which exudes will be larger than in small herniæ, where complete strangulation occurs suddenly. This serum, at first colorless or amber-colored, becomes later stained with blood pigment; may contain flocculi of fibrin or small blood clots; later it becomes cloudy with leucocytes, and after a variable time putrid; migration of bacteria takes place from the interior of the bowel, usually after strangulation has existed for twenty-four hours, sometimes earlier, sometimes later, depending upon the rapidity with which the gut loses its vitality, and especially upon the loss of the lining epithelium of the bowel and the presence of hemorrhages into the intestinal wall. The bacteria found in the exudate are the various forms of pyogenic cocci and the Bacillus coli. Owing to the bactericidal properties of serum, they sometimes possess at first but feeble vitality. The rapidity with which the gut becomes actually gangrenous varies with the completeness of the strangulation. If the blood supply of the bowel is suddenly and completely shut off gangrene may occur in a very few hours. If only gradually, it may be postponed in certain cases for days. The gangrene begins usually in the mucous membrane and spreads to the other coats of the bowel. It may be

localized in small patches here and there or diffuse. Rupture of the bowel then takes place, and the hernial sac is filled with a putrid fluid accumulation, a mixture of the serous exudate and of intestinal contents, gas, and of bacteria. The physical changes in the appearance of the intestine are as follows: As soon as the circulation is seriously interfered with the bowel becomes dark red, and then purple or mahogany in color, the walls of the intestine are edematous. The color changes from bluish-red to greenish- or grayish-black when gangrene is complete. The peritoneum loses its smooth and glistening appearance and becomes rough and dull. Usually at the neck of the sac there is a ringlike groove where the constriction has occurred. Often this area undergoes gangrene very early, and appears as a gray or grayish-black furrow, and here the gangrene takes place from without inward. The gangrenous intestine, if not yet ruptured, is completely paralyzed and distended with gas. A local peritonitis is early developed of the intestinal loop and the walls of the sac. This may spread to the interior of the belly and produce a diffuse septic peritonitis or be shut off by adhesions. As stated, the circulatory disturbances are not always confined to the constricted loop of bowel.

Interference with the mesenteric circulation may lead also to gangrene of portions of the intestine within the abdominal cavity, and the extent will vary between a limited area of the wall of the gut at some particular point and a number of feet. It is quite important for the surgeon to be able to recognize upon opening the hernial sac whether the gut can properly be returned to the abdominal cavity or not. If the fluid contained in the sac is clear and has no bad odor it is a favorable sign. If, on the other hand, it is putrid or contains gas or intestinal contents, it indicates very positively that the condition of the gut will not permit its replacement in the abdominal cavity. If the peritoneal surface of the gut is smooth and bright, although it may be dark red or purple in color, it is a favorable sign. If the bowel is distinctly flabby and paralyzed, entirely wanting in contractility, and if, after the division of the constricting band, no return of circulation in the prolapsed loop occurs after it has been washed with hot salt solution and covered with a hot wet towel for a few moments, it indicates that its vitality is destroyed. In cases of doubt, however, the bowel may be left in the wound, and observed again after an interval of twelve to twenty-four hours. It is to be borne in mind that extensive thrombosis of the vessels of the mesentery may spread within the abdomen, and thus cause gangrene of the bowel and diffuse septic peritonitis. Peritonitis may also occur from distention ulceration (Kocher) of the intra-abdominal intestine leading to the hernial orifice. The afferent loop becomes enormously distended from accumulated contents, gas and feces. Its circulation interfered with by such distention, ulceration, and perforation may follow with fatal results in spite of a successful operation upon the hernia itself. When the gut in the hernial sac becomes gangrenous and ruptures, the mixture of its putrid contents, bacteria-bearing feces and gas, is poured into the sac, and soon sets up a rapidly spreading septic phlegmon or fecal abscess

(assuming that the patient has survived so long). Burrowing of such an abscess in all directions occurs with great rapidity. The skin is extensively undermined and often perforated at several points with the discharge of foul pus, gas, and fecal matter. In this manner it is possible for relief of the obstruction to occur, with the formation of an artificial anus. In partial herniæ (Richter's) such an event may form an artificial anus or fecal fistula, and spontaneous cure is possible, as it is in very rare cases when the entire caliber of the gut is involved. (See my case, vol. i, page 757.) Usually these patients die of septicemia speedily, or after prolonged suppuration.

General Symptoms of Strangulated Hernia.—Although the symptoms of strangulated hernia vary much in different cases, depending upon causes to be discussed later, yet in the average case they are fairly typical. They may be divided into general and local signs and symptoms. The general symptoms are, broadly speaking, the symptoms of acute intestinal obstruction from strangulation; whereas, as has already been pointed out, the symptoms of an *obstructed* hernia resemble those rather of chronic intestinal obstruction. Very often the patient will be able to refer the occurrence of strangulation to some special cause—a violent attack of coughing, an effort to lift a heavy weight, an attack of vomiting, straining at stool, or some other similar incident. The patient during one of these physical efforts will be conscious of an increase in size in the hernial tumor, if such be present, and of severe pain of an *aching* character felt at the site of the hernia; in addition to which there will be *severe colicky* pain, referred to the umbilicus or to the lower part of the abdomen in general. The patient will speedily vomit the contents of his stomach. The vomiting is repeated at frequent intervals, and resembles that from acute intestinal obstruction by strangulation from internal causes—that is to say, it soon becomes bile-stained, is large in quantity, and during the later stages of the condition consists of the contents of the intestine above the obstruction and assumes a fecal character. This material is regurgitated suddenly, without warning, in large quantities and without much apparent effort; it is the typical vomiting of intestinal obstruction. It may be accompanied by hiccough. It may be absent in partial hernia, and may cease when the bowel is gangrenous.

Soon after the onset of strangulation very active peristalsis occurs. The patient has a desire to move his bowels, and a movement occurs, emptying the intestine below the strangulated point. In most cases, after this, *neither gas nor feces pass per rectum*, though the patient may have an intense desire to defecate, and usually makes repeated attempts to do so. In partial hernia there may be diarrhea, and in rare cases of complete hernia, high up in the small intestine, a diarrhea may occur, due to a profuse secretion from the mucous membrane of the bowel below the obstruction; this was designated by Malgaigne as the cholera of strangulated hernia (cholera herniaire). The *degree of abdominal distention* varies greatly, according to the site of the hernia. If it be high up in the small intestine there will be little or no distention, if low down in the large intestine, the distention will be very marked indeed;

the development of peritonitis will be followed by general tympanites. A distinct evidence of increased peristalsis is sometimes observable by auscultation and palpation of the abdomen in the earlier stages of the disease; later, when the intestine is paralyzed or peritonitis has developed, it is abolished.

General Condition.—In many cases the general condition is profoundly affected at once. The patient falls almost immediately into a state of collapse. In other cases the general condition will remain good for a number of hours. When symptoms of collapse come on, the pulse, formerly strong and full, becomes rapid, thready, and compressible. The temperature is usually subnormal, the extremities become cold and moist, the nose looks sharp and pinched, the facial expression is anxious, the mucous membranes assume a bluish, livid color, and this condition of collapse may go on, accompanied by the vomiting and abdominal pain, to a fatal issue, without any other complication. The duration of life in these cases, if not operated upon, varies from less than a day to from five to seven days. If peritonitis is developed the face may become flushed, the temperature may be moderately elevated, or not at all; there will be general tympanites. In some of the cases the patient will feel relatively well, although actually dying, and this condition of hopefulness may endure until the last. In case the gut ruptures into the hernial sac, the patient may still go on and die very rapidly of septicemia, peritonitis, septic pneumonia, and exhaustion. The mortality of untreated cases of strangulated hernia is at least ninety-five per cent. As already indicated, some of the patients die in a condition of collapse during the first day; others, after two or three or more days, of exhaustion; others of peritonitis; others as the result of the rupture of the gut and septic phlegmonous inflammation of the scrotum, abdominal wall, and thighs; still others of pneumonia; and among those where an artificial anus spontaneously forms, especially if it be in the small intestine, some will die of inanition after weeks or months.

Local Symptoms and Changes in the Rupture Itself.—The strangulated hernia becomes larger, more tense, and firmer, and is extremely painful on pressure, there being always a point of fixed pain, most intense in the neighborhood of the neck of the sac. The hernia becomes at once irreducible; there is no impulse upon coughing, nor do any of the other causes, such as vomiting, straining, and the like, produce any change in the tension of the hernial mass. Upon percussion the hernial tumor may be flat, dull, or tympanitic. The chief diagnostic value of irreducibility in strangulated hernia is observed in those cases formerly reducible, which suddenly become irreducible, with the symptoms of pain, general and local, and localized tenderness. It is to be borne in mind that among the aged both the local and general symptoms may be much less marked. The local pain and tenderness may be slight, and if the hernial tumor be very small, it may escape observation altogether. The patients sink into an indolent and apathetic state with gradually increasing symptoms of exhaustion and final collapse. If the intestine ruptures into

the sac, the overlying soft parts rapidly become swollen, red, edematous, and crepitant on palpation; one or more spots, at first of a dark red or mahogany color, are observed upon the skin, and these become gangrenous and softened, the abscess finally rupturing at one or several points. The onset of peritonitis from perforation into the abdominal cavity or the spread of infection from the hernial sac does not differ in its general and local signs from those already described under Diffuse Peritonitis. Among the fatal complications are pneumonia, usually of the septic lobular type, sometimes pyemic from the lodgment of small emboli from the mesenteric vessels. Suppression of urine is not infrequent in the aged, and in all cases of strangulated hernia the amount of urine excreted is notably diminished.

Diagnosis of Strangulated Hernia.—In the majority of cases of strangulated hernia the presence of a hernial tumor, which suddenly becomes irreducible with the typical symptoms already described, presents no diagnostic difficulties. Still, atypical cases occur, and many good surgeons have made grievous errors in diagnosis. The risk of falsely assuming that a hernia is not strangulated is, of course, a far greater peril for the patient than is the assumption that a hernia is strangulated when it is not; the latter error rarely doing any serious harm, the former will probably cost the patient his life. The best means of avoiding error is a careful and thorough examination. It is to be borne in mind that two or more herniæ may exist at the same time, and that one of them may be strangulated, and that that one may be so small as to escape observation. *It is therefore highly important when a patient is suddenly seized with symptoms indicating strangulation of the bowel to examine with care not only the ordinary sites of hernia, but also the unusual sites.* In cases of very small herniæ, and notably those in unusual situations, it may not be possible to detect a tumor, but merely an increased sense of resistance and a fixed point of pain and tenderness. The signs derived from percussion are not of great diagnostic value. The hernia may be empty at the time it becomes strangulated, or at least contain no gas. Under these circumstances it will be dull or flat upon percussion. The tympanitic note may be covered up by the serous exudate in the hernial sac. In certain types of strangulated hernia the characteristic symptoms may be masked or modified. The following classes of cases of this character are quoted from Blake:

I. Cases in which the peculiarities are dependent upon the contents of the sac.

A. Strangulation of a portion of the bowel.
   (*a*) Partial enterocele (Richter's herniæ).
   (*b*) Strangulation of the vermiform appendix.
   (*c*) Strangulation of Meckel's diverticulum (Littre's hernia).

B. Strangulation within the body of the sac.
   (*a*) By bands, adhesions, apertures in omentum, etc.
   (*b*) By kinks or volvulus.

II. Cases in which the peculiarities are dependent upon the sac.

(*a*) Strangulation within a loculus or pouch of the sac.

A. *Strangulation of a Portion of the Bowel.*—(*a*) In these cases the hernia is always small, and has a narrow rigid orifice. It is rarely seen in inguinal hernia, is fairly common in femoral hernia, and has been observed in obturator hernia. There is seldom a definite history of the former presence of hernia, and the attack comes on suddenly as the result of one of the types of muscular effort already indicated. It sometimes happens that the symptoms of intestinal obstruction are absent or not marked, while the local symptoms are quite characteristic. Nevertheless, at the very beginning the patient may exhibit very distinctly the evidences of abdominal shock. Not operated upon, these partial herniæ almost invariably end in gangrene of the gut. The intestine forms the sole contents of the hernial sac, and upon operation a lateral pouch or projection of the wall of the intestine is discovered in a strangulated condition, and frequently so drawn out as to resemble a diverticulum. (*b*) No characteristic signs and symptoms can be given to indicate the presence of a strangulated hernia of the vermiform appendix other than the local signs of a small hernia, painful and tender on palpation and without the symptoms of intestinal obstruction until such time as peritonitis has developed. II. (*a*) In cases where a portion of a hernia becomes strangulated in a lateral pouch of a hernial sac the general symptoms will be the usual ones. There will be localized pain and tenderness in the hernia, but a portion of it may still be reducible. There may be gurgling and tympanitic resonance on percussion.

Strangulation of the Omentum Alone.—The omentum may become strangulated when it is suddenly forced through a hernial aperture by violent muscular contraction, and is subsequently pinched by the hernial ring; or when by a similar mechanism an additional portion of omentum descends into a hernial sac already occupied by a part of the same structure. The strangulation gives rise to disturbances of circulation, swelling, thrombosis of the vessels of the omentum, sometimes to gangrene and suppurative inflammation in the sac. The production of gangrene in the omentum is usually a much slower process than is the case with the intestine. The symptoms are very much less severe than in strangulated hernia of the gut. There is localized pain and tenderness, abdominal pain, sometimes referred to the epigastrium; the hernial tumor is flat upon percussion; it becomes larger and harder. It is usually possible to feel the indurated nodular masses of omentum in the sac quite different from the rounded, smooth, tense, and elastic quality of intestine. Although these patients vomit, the bowels continue to move, and they do not pass into a condition of shock. After the symptoms have existed for a number of days the process may end in resolution, after which the omentum will no longer be reducible, from causes already described. If gangrene or suppuration occurs, a relatively rare happening, there will be the development of a phlegmonous inflammation of the sac and overlying soft parts, giving the characteristic signs

and symptoms of this condition as elsewhere described. A spread of the septic process to the peritoneum and peritonitis is possible. In a few cases only the general symptoms have been severe and marked from the start, resembling those of strangulation of the gut.

Certain other groups of cases and conditions may be mentioned as leading to possible errors of diagnosis, as enumerated by Eccles:

1. Cases with multiple hernia, one irreducible, the other strangulated.
2. Two herniæ, one covering up or concealing the other.
3. An inguinal and a femoral hernia on the same side; one strangulated, the other not.
4. Cases with an irreducible hernia in which the obstruction or strangulation has occurred inside the belly, and not in the hernia itself.

The differential diagnosis between strangulated hernia and other special conditions will be spoken of when describing special forms of hernia. A few words in regard to the choice of treatment in strangulated hernia may not be out of place.

Treatment.—In a general way it may be said that the reduction of strangulated hernia by taxis is no longer regarded as the safest method of treatment. That is to say, there are certain very serious risks attending its use not involved in a cutting operation. Taxis may be tried in cases: (1) Where the general and local symptoms are slight. (2) Where the hernial ring is very large, and where the hernia was formerly reducible, or has been strangulated before and reduced by taxis. (3) Cases in which there are marked general contraindications and difficulties in the operation, such as are found in feeble old people with large herniæ. (4) In young infants. (5) When, the hernia having been formerly reducible, the surgeon is called very soon, within an hour or two, after strangulation has taken place. Taxis is contraindicated: (1) When it has already been tried. (2) When the symptoms have come on suddenly and severely, notably in very small herniæ in which strangulation has existed for so many hours that the gut is probably gangrenous. The limit is ordinarily placed at twenty-four hours. This period would appear to me to be too long. (3) In all cases where the hernia has been previously irreducible. The dangers of taxis are: (1) The rupture of an already friable or gangrenous intestine. (2) The forcing of an intestine back into the abdomen, where it subsequently ruptures and produces peritonitis. (3) The transference of infected fluid in the hernial sac into the abdominal cavity. (4) Reduction *en masse*. (5) Rupture of the mesentery with serious hemorrhage into the abdominal cavity. (6) Rupture of the sac, so that its contents are forced into the surrounding tissues. By reduction *en masse*, or apparent reduction, is meant that the sac, together with its contents, are forced through the hernial canal and come to lie between the transversalis fascia and the anterior abdominal wall, producing a form of interstitial hernia, while the neck of the sac still remains as a constricting band about the intestine. The sac and its contents may also be forced back into the free abdominal cavity, where they may remain still

strangulated. Other possibilities are that the sac ruptures near its neck, and its contents are forced into the retroperitoneal tissues, or that the parietal peritoneum and the sac as well rupture along circular lines, leaving the constricted neck still surrounding the intestine.

Taxis is known to have been successful when the tumor disappears with a gurgling sound into the interior of the abdomen, and its former site is entirely emptied. It is usually possible for the surgeon to follow the hernial canal to and through the hernial ring after reduction is complete. A further and most important sign of success is the speedy relief of the symptoms of strangulation and a normal movement of the bowels. Should the surgeon decide to employ taxis he will use the utmost gentleness in his manipulations. His efforts should not be continued more than three or four minutes. He should be ready to operate at once if the taxis fails. At the present time surgeons are in the habit of treating cases of strangulated hernia by an open operation in all but very exceptional cases. In regard to the operative treatment of strangulated hernia, it may be said that if the patient's condition is very feeble local anesthesia should be employed, if possible. The incision should be liberal through the skin. The constricting band should be divided from without inward rather than in the opposite direction; a liberal exposure of the sac and its contents should be made, so that all the work may be done under the control of the eye. After the division of the constriction the surgeon determines the condition of the strangulated intestine by the rules already indicated. Should the gut be in such condition as to permit returning it to the abdomen one or other of the radical operations for hernia is performed, according to the anatomical site. Should the gut be gangrenous, immediate resection of the intestine gives better results than the formation of an artificial anus. Thus, Gibson, 1900 (*Annals of Surgery*), found that in 101 cases where an artificial anus was formed there were 53 deaths, a mortality of 52.5 per cent. In 226 cases where primary resection and reunion of the intestine was made at the time there were 58 deaths, a mortality of 26 per cent. The large number of deaths following the formation of an artificial anus are due not only to the conditions present at the time of operation, but also to the large number of deaths which occur from inanition when the gangrene affects the middle or upper portion of the small intestine, and further to the dangers accompanying the operative measures for the subsequent closure of the artificial anus. When the gut is found to be gangrenous the incision through the abdominal wall should be liberal, so that the surgeon may inspect thoroughly the intestines still within the abdomen. Resection should be done at a point removed some little distance on either side from that portion of intestine whose nutrition is visibly impaired. The decision on the part of the surgeon as to whether he will make an artificial anus or do a primary resection will also depend to some extent upon his personal skill and experience in intestinal surgery.

SPECIAL FORMS OF HERNIA

Inguinal Hernia.—By inguinal hernia we understand those forms of hernial protrusion which pass into or through the inguinal canal. (For the detailed anatomy of the inguinal canal the reader is referred to works on anatomy and to larger works on general surgery.) A few details are necessarily given here in order that the various forms of hernia in this region may be understood.

In the early months of fetal life a pouch or process of parietal peritoneum is found projecting from the abdominal cavity beneath the skin of the groin (the scrotum in the male and the labium majus in the female). Later on the testis descends along this process of peritoneum, the so-called funicular process (processus vaginalis peritonei), and the lower portion of the peritoneal pouch forms the tunica vaginalis testis. Normally the upper portion becomes obliterated, but if such obliteration does not occur, the tunica vaginalis remains in open communication with the interior of the belly through the inguinal canal, and a portion of abdominal contents may descend through this canal, constituting, as already stated, a congenital hernia, though the protrusion may not occur until adult life. In females the canal is known as the canal of Nuck. Incomplete closure of the peritoneal process gives rise to hydroceles of the cord and to other conditions to be spoken of later.

The abdominal wall in the inguinal region consists of the skin and subcutaneous tissues, the aponeurosis of the external and internal oblique muscles, the transversalis muscle, and the transversalis fascia. The inguinal canal contains the vaginal process of peritoneum in early fetal life, and later the spermatic cord or round ligament passes between these anatomical layers. Its inner opening, the internal abdominal ring, is an orifice in the transversalis fascia just large enough to permit the passage of the cord. The outer end of the canal, the external abdominal ring, is an elongated aperture in the aponeurosis of the external oblique muscle. The internal abdominal ring lies about halfway between the anterior superior spine of the ilium and the spine of the pubis, and about two thirds of an inch above Poupart's ligament. The external ring lies just above and to the outer side of the spine of the pubis. The deep epigastric artery passes upward behind the internal border of the external ring in front of the peritoneum and behind the transversalis fascia. The inguinal canal is about 1.4 inches in length, and is slightly longer in females than in males. At its beginning its anterior or ventral wall is formed by the thick muscular fibers of the internal oblique and transversalis muscle, and its posterior wall by the transversalis fascia. At the middle of the canal the posterior wall is the transversalis fascia, but the internal oblique and transversalis muscle lie above it, and its anterior or ventral wall is formed by the aponeurosis of the external oblique. At its superficial termination the canal passes through the external oblique; its posterior wall is formed by the transversalis fascia, strengthened in the last half inch by the conjoined tendon and the triangular ligament. As the canal becomes more superficial its floor is formed for two

thirds of its extent by the shelf of tendinous fibers of the external oblique, which broadens out to form Gimbernat's ligament.

The greater portion of the posterior or dorsal wall is formed by the transversalis fascia, which is here developed into a layer of considerable strength. Toward the median line the fibers of transversalis fascia are vertical. Laterally they consist of numerous fibers curving around the internal ring. Between these two parts there is a weaker portion lying to the inner side of the deep epigastric artery, and furnishing the avenue through which direct inguinal herniæ escape. The protection of the internal ring consists very largely of the internal oblique muscle, and to a small extent only of the transversalis muscle; and it is especially the internal oblique muscle, not the so-called conjoined tendon, which is utilized in Bassini's operation, being drawn down by sutures to Poupart's ligament to form a new posterior wall for the inguinal canal. (Anatomical details adapted from Joseph A. Blake, "Hernia," "Reference Handbook of the Medical Sciences," William Wood & Co.)

Oblique Inguinal Hernia.—Oblique inguinal herniæ follows, in man, the same path into the scrotum formerly pursued by the testis; that is, through the inguinal canal, and may finally reach the bottom of the scrotum; and nearly all oblique inguinal herniæ, if they reach a considerable size, pass directly along the cord to the vicinity of the normally placed testis. The anatomical layers covering an oblique herniæ are the same as those which cover the spermatic cord. They are from within outward, the infundibuliform fascia, a prolongation of the transversalis fascia; the cremasteric fascia and the cremaster muscle, derived from the internal oblique; and the intercolumnar fascia, derived from the external oblique. The coverings of a direct inguinal hernia are the same, except that the transversalis fascia itself takes the place of the infundibuliform fascia. The various structures of the cord are spread out to a greater or less extent over the surface of a hernial protrusion, the vas deferens lies to the outer side and posteriorly, while the blood-vessels of the cord lie to the outer side of the sac. In the scrotum, however, these relations may be changed, and the entire cord may come to lie in front of the hernia. When the hernia passes through the entire length of the inguinal canal it is known as an *external or oblique inguinal hernia.* When it passes directly forward through the weak portion of the transversalis fascia to the inner side of the deep epigastric artery it is known as a *direct inguinal hernia.* The direct inguinal herniæ are always acquired, the indirect may be either congenital or acquired. The indirect hernia may be divided into several classes, according to the extent and anatomical limits of the protrusion. In the earliest stages of oblique inguinal hernia it is usually possible to invaginate the skin of the scrotum or labium, as the case may be, and to enter the inguinal canal through the external ring.

Examination of Inguinal Hernia.—For making the examination of inguinal hernia in general the patient stands upon his feet in front of the surgeon, who sits conveniently upon a chair with the patient facing toward his right, if the hernia is upon the left side, or toward his left, if the hernia is upon

the right side, and makes the examination with his right or left forefingers respectively. The tip of the finger invaginates the scrotum, finds the external ring, and is then pushed onward into the inguinal canal. In the earliest and slightest cases, when the patient is requested to cough, a distinct impulse is felt at the internal ring by the examining finger. The mere appreciation of an impulse is hardly sufficient to make a diagnosis of hernia, but if the impulse is notably greater on one side than the other, it indicates at least a tendency toward the production of a hernia upon that side or a hernia in its incipient stage. If the hernia is a little farther advanced, a portion of abdominal contents may be felt to enter the inguinal canal at the moment of coughing, but returns instantly to the abdomen. With a relaxed abdominal wall it is sometimes possible in these cases to insert the finger through the internal ring into the abdominal cavity. If the surgeon simply inspects the abdominal wall during coughing, it is sometimes possible in these cases to see a slight rounded protrusion, which immediately disappears. The external ring is often notably increased in size, and there is in many of these cases a distinct relaxation of the abdominal wall. When operating upon a patient of this kind, who has a well-marked hernia upon one side, if the conditions such as have just been noted are found upon the other, it is at present considered wise and justifiable to operate upon both sides.

Fig. 38. — Oblique Inguinal Hernia (Scrotal Type). (Roosevelt Hospital, collection of Dr. Charles McBurney.)

The third grade of inguinal hernia is when the inguinal canal is continuously occupied by the hernia, which, however, forms no external prominence on the abdominal wall. This type is known by various names: incomplete hernia, interstitial hernia, hernia of the inguinal canal. When slightly further advanced, a rounded swelling is appreciable in the inguinal region, sometimes extending as far as the external abdominal ring, but not descending into the scrotum or labium, as the case may be. This form is known as bubonocele. When the hernia descends into the scrotum, it is known as a complete hernia, sometimes as a scrotal hernia. Sometimes scrotal hernia may reach

a very large size, so that a large part of the intestines descend into the scrotum, forming a rounded pendent tumor, which may reach almost or quite to the knees. Upon the surface of such a tumor the preputial orifice may only be discoverable as a dimple, the penis being entirely covered and out of sight. In such herniæ the hernial ring is usually very wide; in some cases large enough to admit the entire fist. These herniæ usually form adhesions, so that they are not reducible; and also because, as already stated, so large a proportion of the abdominal contents lie habitually outside the belly that the abdominal cavity becomes permanently contracted and too small to contain the habitually herniated intestines. This condition is known as *eventration*. These herniæ are, as a rule, inoperable. From the very large number of arterial trunks contained in the hernia, the whole tumor may exhibit visible and palpable pulsation.

Congenital Inguinal Herniæ in the Male.—When the vaginal process of peritoneum remains open after birth it may at any time receive a hernial protrusion. The actual presence of a hernia at birth is, however, quite rare; usually the hernia does not occur until a later period; sometimes not until adult life. It has been found by the examination of infants at birth and thereafter that a complete or partial failure of obliteration of the vaginal process is extremely common; and while the results of the observations of various observers differ quite a little, the following statistics are not devoid of interest: P. Camper found in examining 70 new-born children that in 34 cases the process of peritoneum remained open on both sides, in 14 cases upon the right side, in 8 cases upon the left side. Féré found among 188 children up to the ninth year of life, in 59 cases either a total or partial failure of obliteration. Ramonède examined 215 children or adults, and found among these the process entirely open in 32 cases and only partially closed in 26. Bull and Coley found in 500 cases of inguinal hernia operated upon in children under fourteen years of age that less than fifty per cent of these were

FIG. 39.—LARGE IRREDUCIBLE SCROTAL HERNIA.
(New York Hospital, service of Dr. Frank Hartley.)

congenital. The congenital herniæ present at birth are very rare. In nearly all of these cases adhesions are found, sometimes as mere cords, sometimes as broad adhesions between the contents of the hernial sac and the testis.

The *obliteration*, when it does occur, may be partial or complete. In this connection Sachs divided the vaginal process of peritoneum for purposes of description into four parts: (1) The funnel-shaped process at the internal abdominal ring. (2) The inguinal portion lying in the inguinal canal. (3) The portion along the course of the cord in the scrotum. (4) The portion in immediate relation with the testis.

FIG. 40. — REDUCIBLE INGUINAL HERNIA. (Roosevelt Hospital, service of Dr. Charles McBurney.)

Numerous possibilities exist in regard to the obliteration of these several parts. (1) Obliteration may occur only in the middle of the funicular process, that portion in the middle of the cord between the external ring and the testis; in these cases a funnel-shaped depression may exist at the internal ring; the tunica vaginalis testis remains open and extends upward an unusual distance. In the second variety, the most frequent form, the peritoneal sac remains open through the inguinal canal, below which the process is obliterated as far as the tunica vaginalis. In the third variety the inguinal portion alone is obliterated. In the fourth variety a small funnel-shaped process merely exists at the internal ring; the remainder is obliterated. Irregular forms also occur in which obliteration has failed in one or more spots along the course of the cord, and these serous cavities may

FIG. 41.—HYDROCELE OF THE TUNICA VAGINALIS TESTIS.

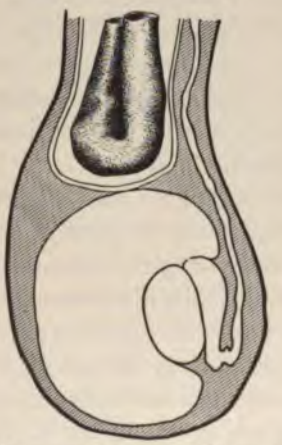


FIG. 42.—ACQUIRED INGUINAL HERNIA WITH HYDROCELE OF THE TUNICA VAGINALIS.

be filled with watery fluid, *encysted hydrocele of the cord.* Be the conditions as they may, certain it is that a large proportion of the hernia occurring in little boys are of the congenital variety.

The commonest and simplest form of congenital hernia in the male is when the entire process remains open, and the hernial contents descend to the bottom of the scrotum lying in contact with the testis. In some cases one finds at operation a hernial sac which communicates below with the tunica vaginalis testis by a narrow opening. In these the lower pouch may become filled with serous fluid, which slowly or rapidly drains back into the abdominal cavity when the patient lies down. In other cases the hernial sac will terminate below in a fibrous cord running into the upper part of the tunica vaginalis testis. When operating upon cases of congenital inguinal hernia one finds usually a very thin sac closely adherent to the elements of the cord and separated only with considerable difficulty; the vas deferens lies posteriorly, as a rule, and the veins are spread out upon the external and posterior surface of the sac. It is not, however, always possible to distinguish, even at the time of operation, between an acquired hernia and that type in which the process remains congenitally open merely a certain distance down the cord, but short of the tunica vaginalis. Before operation it is seldom if ever possible by the physical signs to distinguish the congenital from the acquired form of inguinal hernia.

Another form of inguinal hernia exists, sometimes known as infantile hernia. It is always an acquired hernia. In infantile hernia the processus vaginalis may be entirely open or partly obliterated, but the hernia occurs in an acquired sac. Thus in these cases it might happen that the hernia would appear to be surrounded by a double sac.

Certain congenital defects relating to the testis and to the tunica vaginalis —namely, undescended testis or misplaced testis and hydrocele—have a rather important practical relation to hernia. The descent of the testis may be abnormal or incomplete. The testis may fail to leave the abdomen, and may remain in the iliac or lumbar region. It may descend a variable distance into the inguinal canal; it may leave the canal and lie upon the pubes or beneath the skin of the thigh or in the perineum. These congenital defects in the descent of the testis are frequently associated with an unusually wide inguinal canal, the processus vaginalis descends below the testis, and may remain open in these cases a variable distance and give rise to a congenital hernia. In the cases where the testis remains in the inguinal canal, it may often be pushed out of the external ring, but usually returns at once to its former situation, and this condition is not infrequently accompanied by a congenital hernia, in which the hernial sac lies in front of the testis. Certain practical interest attaches also to the cases where the processus vaginalis remains open throughout, but is extremely narrow at some point, so that serous fluid accumulates in greater or less quantity below the narrow point. If the opening is large, fluid will only accumulate when the individual stands erect, and will run back into the abdom-

inal cavity more or less completely when he lies down. If the communication is very narrow, the fluid will run back but slowly, and it is possible in these cases to confound the condition with an irreducible hernia, or with a hernia which is reduced only with difficulty. The differential diagnosis is to be made by the light test and by the fact that when a hernia leaves the abdominal cavity and descends into the sac, it usually does so suddenly and at once, upon coughing, straining, or the like; whereas, in the case of these communicating hydroceles, the accumulation, having once been emptied into the belly, returns but slowly. Still another combination may exist. The upper portion of the vaginal process may be the seat of a hernia which communicates by a narrow orifice with the tunica vaginalis below, and serous fluid may accumulate in this lower portion of the sac.

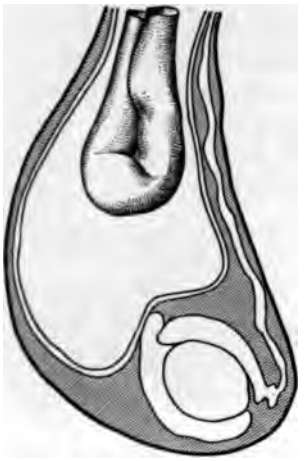


FIG. 43.—ACQUIRED INGUINAL HERNIA WITH AN ACCUMULATION OF FLUID IN THE HERNIAL SAC.

FIG. 44.—CONGENITAL HERNIA WITH HYDROCELE OF THE HERNIAL SAC.

The various forms of hydrocele are occasionally confounded with hernia. The simplest form, hydrocele—i. e., of the tunica vaginalis testis—occurs very commonly among children, but also during later life. It forms a rounded or ovoid tumor, elastic, tense, and fluctuating, transmits light readily, unless the sac be very thick, is insensitive and irreducible, and shows no impulse on coughing. In some cases, if the vaginal process remains open a considerable distance along the cord, the tumor will end above in a more or less spindle-shaped prolongation. The presence of the testis may be determined, usually by palpation, as a firm ovoid mass, and also quite definitely by the sensations of the patient. If the testis be squeezed between the fingers the peculiar and rather indescribable testicular sensation is produced, easily recognizable by the patient. The sensation, if firm pressure is made, amounts to actual pain, and may produce slight faintness. A hydrocele is flat upon percussion. In using the light test one should be cautious in assuming that no hernia is present in little children, because, as already noted, light is freely transmitted through the gut

in infants. When the hydrocele extends far up the cord into the inguinal canal, for example, the difficulties of diagnosis may be rather greater, and this will be especially the case if two sacs exist, one above and one below, communicating by a narrow orifice or not communicating at all. This condition is known as bilocular hydrocele. Occasionally the upper portion of such a sac may communicate with the abdominal cavity, and may thus be reducible. It is not to be forgotten that various forms of hydrocele may be associated with hernia, and that the sac of the hydrocele may bear various and often rather complicated relations to the hernial sac itself. Some of these conditions are rather puzzling to the surgeon, and many of them only permit of a diagnosis by an open operation. The appended series of diagrams illustrate the several possibilities. One of the classical forms of the condition was first described by Sir Astley Cooper, and was designated by him encysted hernia. He assumed that there existed a congenital inguinal hernia, and that the processus vaginalis was closed merely at the external inguinal ring, remaining open above and below. As such a congenital hernia makes its way farther downward into the scrotum, it presses upon the extensive hydrocele of the cord existing below, and may finally cause a depression in the hydrocele sac, such that in the end the walls of the hydrocele come to be an outside double serous covering for the lower portion of the hernia.

Interstitial Hernia.—This is an unusual form of inguinal hernia, in which the sac occupies a position between the layers of the abdominal wall. It is said to occur about once in 1,100 cases. Relatively, it is somewhat more common in females than in males. Three varieties are recognized: (1) The sac insinuates itself between the transversalis fascia and the parietal peritoneum. (2) The sac lies between the internal oblique muscle and the aponeurosis of the external oblique. This is the most frequent form. (3) The sac lies between the aponeurosis of the external oblique and the skin.

The first variety was termed by Krönlein *properitoneal* hernia. Varieties 2 and 3 produce an external, visible, and palpable tumor. In the properitoneal variety no visible protrusion is present, and this form is very commonly associated with a scrotal or labial hernia. Indeed, the sac of a properitoneal hernia is quite commonly a secondary pouch communicating with the sac of an ordinary hernia. The danger of producing this form in the attempt to reduce a strangulated hernia has already been noted, and in several instances such an apparent reduction has been the cause of the patient's death. In a large proportion of the cases of properitoneal hernia, according to Macready in sixty-seven per cent of the cases in males, there was incomplete descent of the testis. Incomplete closure of the canal of Nuck usually coexists in females. Varieties 2 and 3 may attain a very considerable size. They are seldom successfully treated by mechanical means, and usually require an operation.

Direct Inguinal Hernia.—In this form of hernia the condition is never congenital, but always acquired. It is very rare in children, and seldom is developed until adult life. It is more common in men than in women. As

compared with the indirect or oblique form of inguinal hernia, its frequency is said to be seventeen oblique to one direct. As already noted, the protrusion occurs not through the inguinal canal, but directly forward to the inner side of the deep epigastric artery, and so through the external abdominal ring. The differences in the coverings of the sac have already been noted. Direct inguinal hernia is rare before the fortieth year of life, and usually occurs in individuals with a flabby and feebly developed abdominal wall. It is never a sudden, but always a gradual protrusion. It quite frequently occurs upon both sides. The shape of the hernia is often spherical. It seldom attains a large size, and tends to spread toward the median line rather than downward into the scrotum. Indeed, if we see a hernia of considerable size protruding through the external abdominal ring, but not descending into the scrotum, the probabilities are that it is a direct hernia. The diagnosis can sometimes be made by inserting the forefinger into the external ring and feeling the pulsation of the deep epigastric artery to the outer side. The sac of direct inguinal hernia bears no such intimate relations to the structures of the spermatic cord, as is the case with oblique inguinal hernia. The cord lies to the outer side or behind the hernia, and quite separate and distinct from it. Although these herniæ seldom attain a size larger than a goose egg, large and quite commonly double, direct inguinal herniæ have been observed. They are very much less likely to become strangulated than the oblique variety.

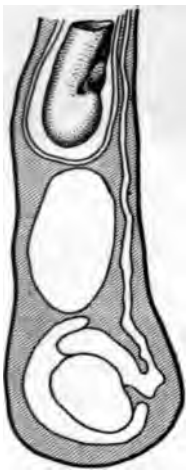


FIG. 45.—ENCYSTED HYDROCELE OF THE CORD WITH ACQUIRED INGUINAL HERNIA.

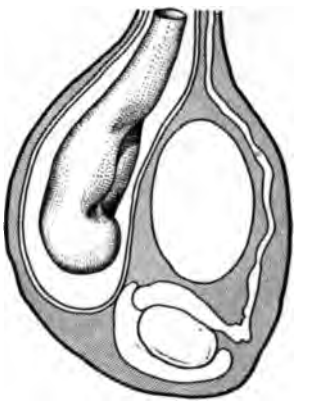


FIG. 46.—ACQUIRED INGUINAL HERNIA LYING IN FRONT OF AN ENCYSTED HYDROCELE OF THE CORD.

Inguinal Hernia in the Female.—The occurrence of inguinal hernia in female children is relatively rare. It is not usually possible to distinguish even at the time of operation whether these herniæ are congenital or acquired. In later life, after the twenty-fifth year, inguinal hernia in the female is more common. Repeated pregnancies appear to be a predisposing cause. As the hernia increases in size it passes through the same grades as in the male, except that it finally descends into the labium majus, in only about four per

cent of the cases, however. These hernia rarely attain a large size, and even when they descend into the labium very large sacs are seldom observed. Instead of descending into the labium they may, in case the tissues are very lax, descend beneath the subcutaneous tissue of the thigh. Strangulation and irreducibility is relatively rare in inguinal hernia in the female. Operation produces almost uniformly satisfactory results in nonstrangulated cases. Hydrocele also occurs in the female from imperfect obliteration of the canal of Nuck; and, as in man, hernia and hydrocele may exist in the same case. The differential diagnosis of hydrocele of the canal of Nuck from hernia is usually not difficult. The hydrocele tumor is globular or ovoid in shape, is freely movable, is situated in the inguinal canal, or may be readily pushed into the

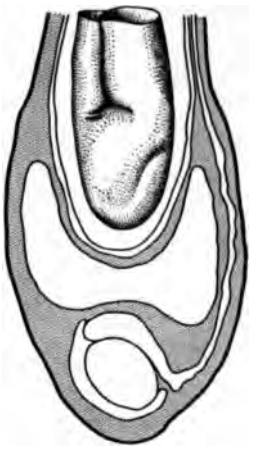


FIG. 47.—ACQUIRED HERNIA, THE SAC SURROUNDED IN ITS LOWER PART BY AN ENCYSTED HYDROCELE OF THE CORD.

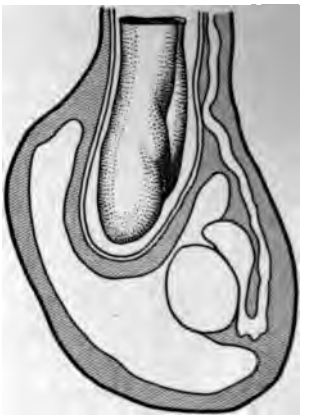


FIG. 48.—ACQUIRED HERNIA IN THE LOWER PORTION OF THE SAC SURROUNDED BY A FLUID ACCUMULATION IN THE TUNICA VAGINALIS TESTIS.

canal; it is rarely, if ever, reducible into the abdominal cavity; it gives the sense of elastic fluctuation on palpation. There is a history of a slow and painless growth without any of the symptoms which commonly accompany hernia.

Femoral Hernia.—In femoral hernia the sac descends within or alongside of the femoral sheath inclosing the femoral vessels. The most common situation is through the femoral canal to the inner side of the femoral vein, rarely in front of or to the outer side of the femoral vessels.

Anatomical Remarks.—The femoral sheath is formed by a funnel-shaped process of the transversalis fascia, which descends below Poupart's ligament in the thigh to inclose the femoral vessels. It is normally funnel-shaped, and at its upper part or base the funnel is not entirely filled by the vessels. At the apex of the funnel opposite the saphenous opening the sheath is closely adherent to the vessels. A space thus exists at the base of the funnel to the inner side of the femoral vein known as the crural canal. It is bounded in front by Poupart's ligament, on the inner side by Gimbernat's ligament, poste-

riorly by the ileo-pectineal line, the so-called Cooper's ligament, and by the fascia covering the pectineus muscle. To the outer side lies the femoral vein.

FIG. 49.—HYDROCELE OF THE TUNICA VAGINALIS TESTES COMPLICATED BY OBLIQUE INGUINAL HERNIA. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

FIG. 50.—TUBERCULOSIS OF TESTIS COMPLICATED BY INGUINAL HERNIA. (Roosevelt Hospital collection of Dr. Charles McBurney.)

This space is filled with loose, fatty connective tissue and contains a small lymph node. Formerly the relation of the obturator or deep epigastric artery to the superior orifice of the crural canal was considered very important from a surgical point of view. The deep epigastric artery ascends to the abdominal wall at the outer side of the canal. In about one third of the cases the obturator artery is a branch of the deep epigastric. In all but three per cent of these cases the obturator passes downward to the outer side of the femoral opening; in the remainder it arches over this opening and passes to its inner side, and thus when operating upon a strangulated femoral hernia the surgeon might wound the obturator artery when dividing the fibers

FIG. 51.—FEMORAL HERNIA. The patient was an old woman; the hernia was recurrent. No operation was done. (New York Hospital collection.)

of Gimbernat's ligament from within, cutting toward the median line to relieve the constriction. At the present period of liberal incisions and of operating under the control of the eye such an accident is not very likely to occur; and, if it is does, the control of the hemorrhage by ligature offers no especial difficulties.

The coverings of a femoral hernia, if it descends through the crural ring to the inner side of the femoral vein, are the peritoneum, the subperitoneal fat, often quite abundant, the so-called septum crurale, the transversalis fascia, the cribriform fascia, the superficial fascia, and the skin. The hernia appears in the thigh below Poupart's ligament and below and to the outer side of the spine of the pubes. *The relations of the hernial protrusion to Poupart's ligament and to the spine of the pubes are the anatomical landmarks whereby we distinguish femoral from inguinal hernia.* The inguinal herniæ escape through the external ring above Poupart's ligament, above and to the inner side of the spine of the pubes. It is usually possible by careful palpation, except in very fat subjects, to recognize the spine of the pubes and its relations to the hernial orifice. When a femoral hernia appears in the thigh it is a small, globular, or hemispherical mass. If it increases in size it tends to ride upward over the falciform process of fascia lata on to the anterior abdominal wall rather than to descend on the thigh, although such a descent is possible, and cases have been observed where a femoral hernia has descended beneath the subcutaneous tissues almost as far as the knee. Most of these herniæ, however, remain of small size, and rarely extend upward farther than Poupart's ligament. Femoral herniæ are more common in women than in men, in the proportion of about three to one up to the age of fifty years, after which the proportions become nearly equal on account of the infrequent formation of herniæ in old women.

Fig. 52.—Femoral Hernia Incarcerated. (New York Hospital, service of Dr. Hartley.)

The statistics of the Hospital for Ruptured and Crippled in the city of New York indicate that inguinal hernia is about seventeen times as frequent as femoral hernia. According to Macready, of 100 ruptures in males 97½ per cent are inguinal and 2½ per cent femoral hernia. Among women the proportion is 60.3 per cent inguinal, 39.7 per cent femoral hernia. A number of rare

the right side, and makes the examination with his right or left forefingers respectively. The tip of the finger invaginates the scrotum, finds the external ring, and is then pushed onward into the inguinal canal. In the earliest and slightest cases, when the patient is requested to cough, a distinct impulse is felt at the internal ring by the examining finger. The mere appreciation of an impulse is hardly sufficient to make a diagnosis of hernia, but if the impulse is notably greater on one side than the other, it indicates at least a tendency toward the production of a hernia upon that side or a hernia in its incipient stage. If the hernia is a little farther advanced, a portion of abdominal contents may be felt to enter the inguinal canal at the moment of coughing, but returns instantly to the abdomen. With a relaxed abdominal wall it is sometimes possible in these cases to insert the finger through the internal ring into the abdominal cavity. If the surgeon simply inspects the abdominal wall during coughing, it is sometimes possible in these cases to see a slight rounded protrusion, which immediately disappears. The external ring is often notably increased in size, and there is in many of these cases a distinct relaxation of the abdominal wall. When operating upon a patient of this kind, who has a well-marked hernia upon one side, if the conditions such as have just been noted are found upon the other, it is at present considered wise and justifiable to operate upon both sides.

Fig. 38. — Oblique Inguinal Hernia (Scrotal Type). (Roosevelt Hospital, collection of Dr. Charles McBurney.)

The third grade of inguinal hernia is when the inguinal canal is continuously occupied by the hernia, which, however, forms no external prominence on the abdominal wall. This type is known by various names: incomplete hernia, interstitial hernia, hernia of the inguinal canal. When slightly further advanced, a rounded swelling is appreciable in the inguinal region, sometimes extending as far as the external abdominal ring, but not descending into the scrotum or labium, as the case may be. This form is known as bubonocele. When the hernia descends into the scrotum, it is known as a complete hernia, sometimes as a scrotal hernia. Sometimes scrotal hernia may reach

a very large size, so that a large part of the intestines descend into the sc forming a rounded pendent tumor, which may reach almost or quite knees. Upon the surface of such a tumor the preputial orifice may o discoverable as a dimple, the penis being entirely covered and out of In such herniæ the hernial ring is usually very wide; in some cases enough to admit the entire fist. These herniæ usually form adhesions, they are not reducible; and also because, as already stated, so large portion of the abdominal contents lie habitually outside the belly th abdominal cavity becomes permanently contracted and too small to c the habitually herniated intestines. This condition is known as *event* These herniæ are, as a rule, inoperable. From the very large num arterial trunks contained in the hernia, the whole tumor may exhibit and palpable pulsation.

Congenital Inguinal Herniæ in the Male.—When the vaginal proc peritoneum remains open after birth it may at any time receive a herni trusion. The actual pr of a hernia at birth is ever, quite rare; usual hernia does not occur later period; sometim until adult life. It ha found by the examinat infants at birth and after that a complete c tial failure of obliterat the vaginal process tremely common; and the results of the obser of various observers quite a little, the fol statistics are not dev interest: P. Camper fo examining 70 new-bor dren that in 34 cases th ess of peritoneum re open on both sides, cases upon the right s 8 cases upon the lef Féré found among 18 dren up to the ninth year of life, in 59 cases either a total or partial fail obliteration. Ramonède examined 215 children or adults, and found these the process entirely open in 32 cases and only partially closed Bull and Coley found in 500 cases of inguinal hernia operated up children under fourteen years of age that less than fifty per cent of thes

Fig. 39.—Large Irreducible Scrotal Hernia. (New York Hospital, service of Dr. Frank Hartley.)

congenital. The congenital herniæ present at birth are very rare. In nearly all of these cases adhesions are found, sometimes as mere cords, sometimes as broad adhesions between the contents of the hernial sac and the testis.

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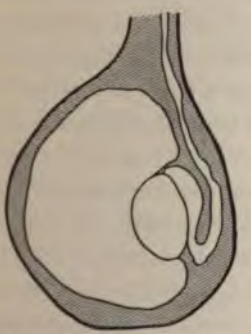

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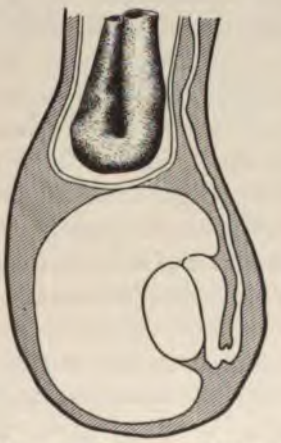

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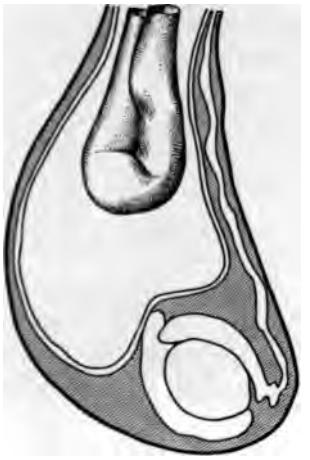

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FIG. 44.—CONGENITAL HERNIA WITH HYDROCELE OF THE HERNIAL SAC.

The various forms of hydrocele are occasionally confounded with hernia. The simplest form, hydrocele—i. e., of the tunica vaginalis testis—occurs very commonly among children, but also during later life. It forms a rounded or ovoid tumor, elastic, tense, and fluctuating, transmits light readily, unless the sac be very thick, is insensitive and irreducible, and shows no impulse on coughing. In some cases, if the vaginal process remains open a considerable distance along the cord, the tumor will end above in a more or less spindle-shaped prolongation. The presence of the testis may be determined, usually by palpation, as a firm ovoid mass, and also quite definitely by the sensations of the patient. If the testis be squeezed between the fingers the peculiar and rather indescribable testicular sensation is produced, easily recognizable by the patient. The sensation, if firm pressure is made, amounts to actual pain, and may produce slight faintness. A hydrocele is flat upon percussion. In using the light test one should be cautious in assuming that no hernia is present in little children, because, as already noted, light is freely transmitted through the gut

in infants. When the hydrocele extends far up the cord into the inguinal c for example, the difficulties of diagnosis may be rather greater, and this be especially the case if two sacs exist, one above and one below, communic by a narrow orifice or not communicating at all. This condition is knov bilocular hydrocele. Occasionally the upper portion of such a sac may municate with the abdominal cavity, and may thus be reducible. It i to be forgotten that various forms of hydrocele may be associated with he and that the sac of the hydrocele may bear various and often rather co cated relations to the hernial sac itself. Some of these conditions are r puzzling to the surgeon, and many of them only permit of a diagnosis b open operation. The appended series of diagrams illustrate the several p bilities. One of the classical forms of the condition was first described by Astley Cooper, and was designated by him encysted hernia. He assumed there existed a congenital inguinal hernia, and that the processus vagi was closed merely at the external inguinal ring, remaining open above below. As such a congenital hernia makes its way farther downward int scrotum, it presses upon the extensive hydrocele of the cord existing b and may finally cause a depression in the hydrocele sac, such that in the the walls of the hydrocele come to be an outside double serous covering fo lower portion of the hernia.

Interstitial Hernia.—This is an unusual form of inguinal hernia, in w the sac occupies a position between the layers of the abdominal wall. said to occur about once in 1,100 cases. Relatively, it is somewhat more mon in females than in males. Three varieties are recognized: (1) Th insinuates itself between the transversalis fascia and the parietal periton (2) The sac lies between the internal oblique muscle and the aponeuros the external oblique. This is the most frequent form. (3) The sac lies bet the aponeurosis of the external oblique and the skin.

The first variety was termed by Krönlein *properitoneal* hernia. Var 2 and 3 produce an external, visible, and palpable tumor. In the pr toneal variety no visible protrusion is present, and this form is very comm associated with a scrotal or labial hernia. Indeed, the sac of a properit hernia is quite commonly a secondary pouch communicating with the s an ordinary hernia. The danger of producing this form in the attem reduce a strangulated hernia has already been noted, and in several inst such an apparent reduction has been the cause of the patient's death. large proportion of the cases of properitoneal hernia, according to Macrea sixty-seven per cent of the cases in males, there was incomplete descent o testis. Incomplete closure of the canal of Nuck usually coexists in fem Varieties 2 and 3 may attain a very considerable size. They are seldom cessfully treated by mechanical means, and usually require an operation.

Direct Inguinal Hernia.—In this form of hernia the condition is n congenital, but always acquired. It is very rare in children, and seldo developed until adult life. It is more common in men than in women.

compared with the indirect or oblique form of inguinal hernia, its frequency is said to be seventeen oblique to one direct. As already noted, the protrusion occurs not through the inguinal canal, but directly forward to the inner side of the deep epigastric artery, and so through the external abdominal ring. The differences in the coverings of the sac have already been noted. Direct inguinal hernia is rare before the fortieth year of life, and usually occurs in individuals with a flabby and feebly developed abdominal wall. It is never a sudden, but always a gradual protrusion. It quite frequently occurs upon both sides. The shape of the hernia is often spherical. It seldom attains a large size, and tends to spread toward the median line rather than downward into the scrotum. Indeed, if we see a hernia of considerable size protruding through the external abdominal ring, but not descending into the scrotum, the probabilities are that it is a direct hernia. The diagnosis can sometimes be made by inserting the forefinger into the external ring and feeling the pulsation of the deep epigastric artery to the outer side. The sac of direct inguinal hernia bears no such intimate relations to the structures of the spermatic cord, as is the case with oblique inguinal hernia. The cord lies to the outer side or behind the hernia, and quite separate and distinct from it. Although these herniæ seldom attain a size larger than a goose egg, large and quite commonly double, direct inguinal herniæ have been observed. They are very much less likely to become strangulated than the oblique variety.

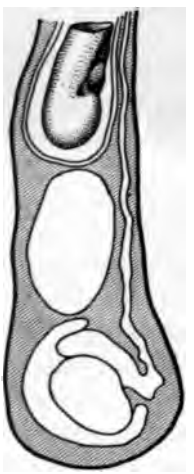

FIG. 45.—ENCYSTED HYDROCELE OF THE CORD WITH ACQUIRED INGUINAL HERNIA.

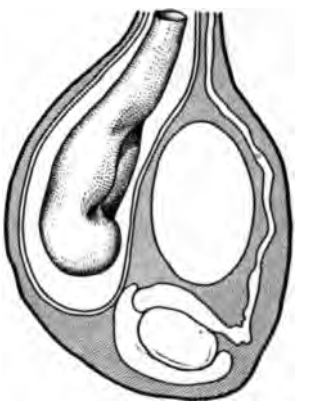

FIG. 46.—ACQUIRED INGUINAL HERNIA LYING IN FRONT OF AN ENCYSTED HYDROCELE OF THE CORD.

Inguinal Hernia in the Female.—The occurrence of inguinal hernia in female children is relatively rare. It is not usually possible to distinguish even at the time of operation whether these herniæ are congenital or acquired. In later life, after the twenty-fifth year, inguinal hernia in the female is more common. Repeated pregnancies appear to be a predisposing cause. As the hernia increases in size it passes through the same grades as in the male, except that it finally descends into the labium majus, in only about four per

cent of the cases, however. These herniæ rarely attain a large size, and even when they descend into the labium very large sacs are seldom observed. Instead of descending into the labium they may, in case the tissues are very lax, descend beneath the subcutaneous tissue of the thigh. Strangulation and irreducibility is relatively rare in inguinal hernia in the female. Operation produces almost uniformly satisfactory results in nonstrangulated cases. Hydrocele also occurs in the female from imperfect obliteration of the canal of Nuck; and, as in man, hernia and hydrocele may exist in the same case. The differential diagnosis of hydrocele of the canal of Nuck from hernia is usually not difficult. The hydrocele tumor is globular or ovoid in shape, is freely movable, is situated in the inguinal canal, or may be readily pushed into the

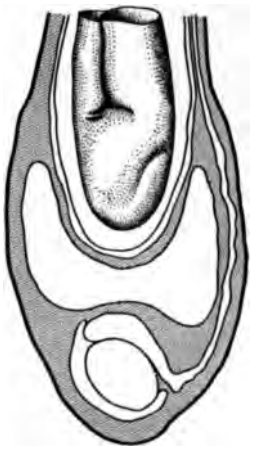

FIG. 47.—ACQUIRED HERNIA, THE SAC SURROUNDED IN ITS LOWER PART BY AN ENCYSTED HYDROCELE OF THE CORD.

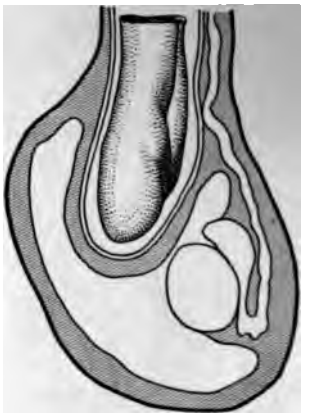

FIG. 48.—ACQUIRED HERNIA IN THE LOWER PORTION OF THE SAC SURROUNDED BY A FLUID ACCUMULATION IN THE TUNICA VAGINALIS TESTIS.

canal; it is rarely, if ever, reducible into the abdominal cavity; it gives the sense of elastic fluctuation on palpation. There is a history of a slow and painless growth without any of the symptoms which commonly accompany hernia.

Femoral Hernia.—In femoral hernia the sac descends within or alongside of the femoral sheath inclosing the femoral vessels. The most common situation is through the femoral canal to the inner side of the femoral vein, rarely in front of or to the outer side of the femoral vessels.

Anatomical Remarks.—The femoral sheath is formed by a funnel-shaped process of the transversalis fascia, which descends below Poupart's ligament in the thigh to inclose the femoral vessels. It is normally funnel-shaped, and at its upper part or base the funnel is not entirely filled by the vessels. At the apex of the funnel opposite the saphenous opening the sheath is closely adherent to the vessels. A space thus exists at the base of the funnel to the inner side of the femoral vein known as the crural canal. It is bounded in front by Poupart's ligament, on the inner side by Gimbernat's ligament, poste-

riorly by the ileo-pectineal line, the so-called Cooper's ligament, and by the fascia covering the pectineus muscle. To the outer side lies the femoral vein.

FIG. 49.—HYDROCELE OF THE TUNICA VAGINALIS TESTES COMPLICATED BY OBLIQUE INGUINAL HERNIA. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

FIG. 50.—TUBERCULOSIS OF TESTIS COMPLICATED BY INGUINAL HERNIA. (Roosevelt Hospital collection of Dr. Charles McBurney.)

This space is filled with loose, fatty connective tissue and contains a small lymph node. Formerly the relation of the obturator or deep epigastric artery to the superior orifice of the crural canal was considered very important from a surgical point of view. The deep epigastric artery ascends to the abdominal wall at the outer side of the canal. In about one third of the cases the obturator artery is a branch of the deep epigastric. In all but three per cent of these cases the obturator passes downward to the outer side of the femoral opening; in the remainder it arches over this opening and passes to its inner side, and thus when operating upon a strangulated femoral hernia the surgeon might wound the obturator artery when dividing the fibers

FIG. 51.—FEMORAL HERNIA. The patient was an old woman; the hernia was recurrent. No operation was done. (New York Hospital collection.)

of Gimbernat's ligament from within, cutting toward the median line to relieve the constriction. At the present period of liberal incisions and of operating under the control of the eye such an accident is not very likely to occur; and, if it is does, the control of the hemorrhage by ligature offers no especial difficulties.

The coverings of a femoral hernia, if it descends through the crural ring to the inner side of the femoral vein, are the peritoneum, the subperitoneal fat, often quite abundant, the so-called septum crurale, the transversalis fascia, the cribriform fascia, the superficial fascia, and the skin. The hernia appears in the thigh below Poupart's ligament and below and to the outer side of the spine of the pubes. *The relations of the hernial protrusion to Poupart's ligament and to the spine of the pubes are the anatomical landmarks whereby we distinguish femoral from inguinal hernia.* The inguinal herniæ escape through the external ring above Poupart's ligament, above and to the inner side of the spine of the pubes. It is usually possible by careful palpation, except in very fat subjects, to recognize the spine of the pubes and its relations to the hernial orifice. When a femoral hernia appears in the thigh it is a small, globular, or hemispherical mass. If it increases in size it tends to ride upward over the falciform process of fascia lata on to the anterior abdominal wall rather than to descend on the thigh, although such a descent is possible, and cases have been observed where a femoral hernia has descended beneath the subcutaneous tissues almost as far as the knee. Most of these herniæ, however, remain of small size, and rarely extend upward farther than Poupart's ligament. Femoral herniæ are more common in women than in men, in the proportion of about three to one up to the age of fifty years, after which the proportions become nearly equal on account of the infrequent formation of herniæ in old women.

FIG. 52.—FEMORAL HERNIA INCARCERATED.
(New York Hospital, service of Dr. Hartley.)

The statistics of the Hospital for Ruptured and Crippled in the city of New York indicate that inguinal hernia is about seventeen times as frequent as femoral hernia. According to Macready, of 100 ruptures in males 97½ per cent are inguinal and 2½ per cent femoral hernia. Among women the proportion is 60.3 per cent inguinal, 39.7 per cent femoral hernia. A number of rare

varieties of femoral hernia have been described: (1) The herniæ may take place through a rent in Gimbernat's ligament. (2) Instead of becoming subcutaneous, the herniæ may burrow beneath the pectineal fascia among the adductor muscles of the thigh. (3) The hernia may occur to the outer side of the femoral artery. (4) The hernia may escape from the pelvis behind the femoral vessels. (5) Two sacs may develop or a dividing sac, one of which follows the crural canal, the other burrows between the peritoneum and the fascia of the pelvis, usually downward in the direction of the obturator foramen.

FIG. 53.—RECURRENT FEMORAL HERNIA.
(New York Hospital, service of Dr. P. R. Bolton.)

The symptoms produced by femoral herniæ are indefinite pains, digestive disturbances, and sometimes acute attacks of colicky pain, referred to the lower part of the abdomen. Inasmuch as these herniæ grow very slowly and do not form large tumors, their existence may remain unsuspected for a very considerable time. When small they are usually easily reducible, but otherwise give the ordinary signs of hernia, when examined carefully in the erect position. Strangulation occurs in femoral hernia, on account of the very narrow orifice, much more frequently than in inguinal herniæ. Thus, among 94 cases of strangulated herniæ Bryant found 50 inguinal and 44 femoral herniæ. The seat of strangulation in femoral hernia may be at the crural ring, the border of Gimbernat's ligament, the falciform process of fascia lata, or in the substance of the cribriform fascia. The two most frequent points are the border of Gimbernat's ligament and the edge of the falciform process. Strangulation of femoral hernia leads very rapidly to gangrene of the bowel, and strangulation of a partial hernia, involving but a portion of the wall of the gut, is not infrequent. The symptoms of strangulation may be far less stormy than is the case with inguinal herniæ, and yet at the operation the bowel may be found gangrenous. *The use of taxis for the reduction of a strangulated femoral hernia is not advisable*, nor can femoral hernia of the reducible kind be cured by mechanical means other than operation.

Differential Diagnosis of Oblique Inguinal Hernia.—While many of the details of the diagnosis of inguinal hernia have already been mentioned, certain of them may bear repetition, and some other conditions not yet described

require notice. The differential diagnosis of femoral from inguinal hernia depends chiefly upon the relations between the hernia and the two anatomical landmarks: the spine of the pubes and Poupart's ligament. In the male the diagnosis is usually not difficult. The external ring may always be felt, and the pubic spine may be located by introducing the tip of the finger into the canal and following the external pillar of the ring to its insertion into the spine of the pubes. In females, if they be stout, the diagnosis is sometimes very difficult or impossible. If the protrusion is above Poupart's ligament, it is an inguinal hernia; if below, a femoral hernia. If Poupart's ligament cannot be felt, a line may be drawn from the anterior spine of the ilium to the spine of the pubes. If the hernia appears to lie above this line it is probably inguinal; if below, femoral.

Hydrocele.—Here it may be said that encysted hydrocele of the cord or of the canal of Nuck can usually be distinguished from hernia readily; the positive signs of hernia—impulse on coughing, reducibility, etc.—are wanting; the tumor is rounded, elastic, movable, and more tense than a hernia, except the latter be strangulated.

Lipomata.—Fatty tumors of the groin will exhibit the physical characters of lipoma—i. e., softness, a lobulated structure, a want of complete correspondence with the anatomical site of hernia, absence of a pedicle or neck, irreducibility. They are usually subcutaneous and attached to the skin. (See Tumors.) Acute and chronic infections and secondary malignant disease of the lymph glands of the groin have been mistaken for hernia. If the glands are discrete, the individual glands can be distinguished. If periadenitis exists, the infiltration is more diffuse, and has less sharply marked boundaries than any hernia. In case of doubt, inspect the lower extremities, the genitals, the anus, for a focus of infection, or a primary malignant growth, and look for pediculi on the genital and anal skin, and for nits in the pubic hair, or for an operation scar, or the presence of a malignant tumor in some other part of the body.

Psoas abscess is often mistaken for hernia. The diagnosis may not be easy. The swelling may occupy the site of hernia, may disappear on lying down; an impulse may be present on coughing. Signs and symptoms of disease of the vertebræ and pelvic bones should be sought for. The following method of examination is useful: The patient is placed on his back and bimanual palpation is made; one hand is used to depress the abdominal wall above the tumor while the other hand makes pressure upon the tumor in the groin; should the latter diminish in size or disappear, an increase of intra-abdominal tension can usually be appreciated with the other hand; in many cases a distinct sense of fluctuation back and forth between the two hands. Under similar manipulations a hernia may be reduced and disappear, but no corresponding increase of intra-abdominal tension will be observed.

Retained Testis.—When the testis occupies the inguinal canal it may resemble or be associated with a hernia. When a small, movable tumor is felt, in

sembling in size and shape a small testis, seek the testicles in the scrotum; if absent, and pressure on the inguinal tumor causes testicular sensations, the diagnosis of retained testis is to be made; the signs of hernia should also be carefully sought for.

Errors of diagnosis between *scrotal hernia* and other conditions are even more common than when the tumor occupies the inguinal canal and groin. Macready tabulated 739 cases in males and 85 in females in which errors in diagnosis were made. Among these, the most common error was mistaking a hydrocele for a hernia, 233 cases; epididymitis was mistaken for hernia 107 times; varicocele 90 times; noninflammatory enlargements of the testis 28 times; tumors of the testis 13 times; tuberculosis of epididymitis or testis 17 times. The following conditions were mistaken for femoral hernia: Enlarged lymph nodes 115 times, abscess 47 times, varicose condition of the saphenous vein 9 times, psoas abscess 7 times. In females the following conditions were mistaken for hernia into the labium majus: Cysts of the labium 12 times, varix of saphenous vein 26 times, psoas abscess 3 times, enlarged glands 22 times.

It thus appears that hydrocele is more frequently mistaken for scrotal hernia than any other condition. Such an error is scarcely likely to occur in simple cases of hydrocele if ordinary care is taken in the examination. To recapitulate the signs: Hydrocele is only reducible under the very rare conditions already described, and then not usually in the same instantaneous manner as hernia. The swelling is in the scrotum, and only rarely extends upward into the inguinal canal. The tense, elastic, fluctuating quality of hydrocele is in most cases quite different from that of any but a strangulated hernia. The light test is efficient in all but infants and children, where, as already stated, the intestine may also transmit light. The method of applying the light test is as follows: An endoscopic tube, a Kelly's tube, or a cylinder of black paper or any similar device is placed against the side of the scrotal tumor and held in the right hand; with the left hand the skin of the scrotum is gathered up posteriorly and put upon the stretch; against the thickest portion of the tumor the surgeon firmly presses the cylinder through which he intends to look. Some source of artificial light—a candle, an electric light, or even a lighted match—is held upon the other side of the scrotum reasonably close to the skin. If serous fluid is present in considerable quantity the skin at the bottom of the tube will appear brightly illuminated. The tumor, in other words, is translucent. *The test fails when the hydrocele sac is greatly thickened or when it contains blood.* In rare cases it is stated that some of the forms of sarcoma of the testis also transmit light. The history is quite important in the diagnosis. In hernia the tumor has progressed and increased in size from above downward. In hydrocele the tumor has originally formed at the bottom of the scrotum in the vicinity of the testis. In cases of reducible hydrocele, by squeezing the tumor it may be felt to slowly diminish in size, or if the patient lies down upon his back a similar diminution and even disappearance may occur. If the patient be then asked to stand upright, while the surgeon

presses a finger over the external ring lightly, the tumor will nevertheless slowly reappear. In cases of very large hydroceles and greatly thickened sacs, when the patients could not give intelligent histories, good surgeons have occasionally been deceived. Strangely enough, inflammation of the testis and of the epididymis appears to be next in frequency as a source of error. The history of an injury to the testis or of a gonorrhea, together with the entire absence of the typical signs of hernia and the physical examination by palpation of the inflamed testis, should be entirely sufficient to establish the diagnosis. (See Diseases of the Testis.)

FIG. 54.—LARGE HYDROCELE OF THE TUNICA VAGINALIS TESTIS. (Collection of Dr. Charles McBurney.)

Varicocele.—While in the majority of instances the diagnosis of varicocele is entirely simple, the characteristic feeling of the veins surrounding the cord like a bundle of angleworms, their contours often visible through the skin, enabling one to make a diagnosis at sight, yet it occasionally happens that a large varicocele may closely resemble an omental hernia. There may be impulse on coughing, the tumor may disappear when the patient lies down and reappear when he stands upright. On palpation a long mass of omentum may feel very like a bundle of varicose veins. The most important differential point is the difference in the character of the impulse on coughing or straining. In hernia this is sudden; in varicocele, it being caused by the flow of blood from the abdomen into the dilated veins, a distinct sensation as of fluid passing through the inguinal canal may often be readily perceived. The sensation is very like that perceived in reducible hydrocele.

In women with varicose veins of the groin, notably of the saphenous vein and its branches, the character of the impulse on coughing is much the same, and a careful observer will rarely be deceived. The following additional diagnostic points are sometimes useful:

When in doubt as to whether a hernia is of the femoral or inguinal variety, if we are able to reduce the tumor we insert our finger into the exter-

nal abdominal ring. This is nearly always possible in men by invaginating the skin of the scrotum; by no means so easy in women. While the finger is in the ring the patient is made to stand upright; if the hernia is of the femoral variety, its sudden reappearance, in spite of the closure of the inguinal canal, establishes its origin. In reducible femoral hernia it is sometimes possible to insert the finger beneath Poupart's ligament and feel the edge of Gimbernat's ligament on the inner side, occasionally the pulsation of the external iliac artery upon the outer side. It is rarely possible to make out the exact character of the contents of the sac further than to be able to say that omentum or bowel, or both, are present. In children when the vermiform appendix occupies the sac it is occasionally possible to identify it. (For further details of diagnosis, see Diseases of the Testis.)

In regard to *femoral hernia*, certain conditions deserve mention; adenitis, psoas abscess, malignant disease of the glands, and lipoma have already been mentioned. In regard to saphenous varix, two additional points may be borne in mind—namely, that the tumor having disappeared when the patient lies down, a finger pressed upon the region of the femoral canal does not prevent the reappearance of the tumor when the patient stands up, although such reappearance is not as sudden as is the case with hernia. An examination of the legs will usually discover a varicose condition of the subcutaneous veins, varix of the saphenous vein being rare as an isolated lesion. Hypertrophy of the fatty tissue in the vicinity of the crural opening is quite a common condition, but is nearly always associated with a small femoral hernia. Thus an error in diagnosis may occur to the extent of assuming that the hernia is irreducible, whereas the mass felt is really not the hernial sac, but a considerable tumor as large as the last joint of one's thumb or sometimes larger, composed of fatty tissue, the hernia itself being very small and reducible.

FIG. 55.—UMBILICAL HERNIA.
(New York Hospital, service of Dr. Murray.)

Umbilical Hernia.—Three varieties of umbilical hernia may be distinguished: (1) Congenital hernia of the cord. (2) Umbilical hernia in infants. (3) Umbilical hernia in adults.

1. *Congenital Hernia of the Cord.*—This condition is due to defective closure of the visceral lamellæ during fetal life, and is, properly speaking, not

a hernia at all, since the parts found outside the abdominal cavity at birth have never been inside the belly. The condition is extremely rare, and is said to occur once in 5,184 births. Two cases were observed in one year at the Hospital for Ruptured and Crippled in the city of New York (Coley). The child may be born with a large part of the abdominal viscera outside the abdominal cavity; the small intestine, the large intestine, the cecum, the liver, the stomach, the spleen, the kidney may all be present. The condition is then known as eventration. In other cases only some part of the small intestine or cecum. On inspection the appearances of the abdomen are peculiar. The tumor is covered by skin up to a certain level, beyond that by a thin translucent membrane, which consists of amnion upon the outer side; beneath this a very thin layer, sometimes containing Wharton's jelly, and as an inner lining a non-vascular structure, which would under normal conditions have been peritoneum. This portion of the covering of the viscera is usually so thin that the character of the contained abdominal contents can be seen. Children born in this condition rarely survive. The sac may rupture during labor, in which case the child commonly dies at once. If it survives, the amniotic portion sloughs and the child dies of peritonitis. The only hope in these cases is an operation, if such can be performed—i. e., if the viscera can be reduced into the abdomen. In some of these cases the protrusion is very small, and a careless ligation of the cord might include a portion of intestine with the production of a fatal result, an artificial anus or a fecal fistula. In addition to the very extensive congenital herniæ of the cord, others are described, which apparently have arisen after the closure of the abdominal cavity during fetal life, the protrusion then following alongside of the blood-vessels of the umbilical cord. Some of these herniæ are of

Fig. 56.—Large Ventral Hernia (Inoperable). (Roosevelt Hospital, collection of Dr. Charles McBurney.)

arge size and have a broad base. Others are small, and project perhaps
or 2 cm. outside the abdomen. In both varieties a portion of the tumor is
d by amnion, nearly translucent and very thin. The diagnosis of these
ions is to be made by inspection and by the increase in the size of the
during crying. (See also Meckel's Diverticulum and Umbilical Fistulæ.)

Umbilical Herniæ among Infants and Little Children.—When we re-
er that the umbilicus is normally closed by the formation of scar tissue,
hat all scar tissue is
sed of a tendency to
n and become thinned
y pressure, it is not
ising that in numerous
ces when the umbilical
s closed by but a thin
of such tissue, herniæ
umbilicus should oc-
Such herniæ may be
d as the result of cry-
oughing, straining dur-
rination, on account of
sis, and other similar
ions. No doubt a large
er of these herniæ oc-
hat are never treated,
the tendency for them
get well spontaneously.
occur during infancy
any time before puber-
In infants, umbilical
is equally common in
exes, and is most com-
luring the first year of
The hernia is a direct

FIG. 57.—LARGE VENTRAL HERNIA IN A WOMAN. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

nd the coverings consist simply of the skin with a very little subcu-
s tissue and the peritoneum behind that. The hernial orifice is al-
small; the herniæ seldom reach a size larger than that of a pigeon's
hey are usually conical in shape; their contents is nearly always small
ne; they are always reducible; they almost never become strangulated;
sually disappear when the child lies down, and only reappear upon
ng, straining, and the like. The diagnosis is, of course, very simple;
nes these children suffer from colic and digestive disturbances, which
ear when the child wears a suitable support. Most of these cases when
rly during infancy recover without the use of trusses or special appa-
Radical operation is only indicated when the simple treatment with

a pad or sticking plaster has failed, and the hernia tends to increase in size as the child grows older.

3. *Umbilical Hernia in Adults.*—As stated, umbilical hernia is very frequent during the earlier years of life; the number then rapidly diminishes, and in males is rare throughout adult existence. When found in men a general predisposition to hernia is commonly present, so that single or double inguinal or other herniæ frequently coexist. In women, on the other hand, while the number of umbilical herniæ steadily diminishes from the age of five until twenty-five, after this period the number again increases, and at forty years of age this is the most frequent form in females. Berger's statistics indicate that after the age of fifteen umbilical hernia constitutes 22.16 per cent of all hernia occurring in females and 2.5 per cent in males. The umbilical herniæ of female adults have quite a different history from those seen in children. The latter remain small, the former tend to increase in size, and may in time reach enormous proportions—as large or larger than a man's head, for example (see illustrations). Such herniæ are usually accompanied by great enlargement of the umbilical ring and by diastasis of the recti muscles. The small infantile type may, however, occur in both men and women; these latter are far less dangerous and rarely require operation. The large umbilical herniæ appear to be due to intra-abdominal pressure, especially to repeated pregnancies, occasionally to intraperitoneal exudates, ascites, large abdominal tumors, etc. These herniæ may form rounded prominences; in other cases they spread laterally in the subcutaneous tissues of the abdominal wall, and may take an irregular shape with pockets and prolongations extending in various directions. The hernial orifice may be large enough to admit a fist, or larger. In rare cases a properitoneal pouch has been observed in addition to the subcutaneous sac. The covering of these herniæ consist of skin and peritoneum merely, only a little connective tissue remaining to represent the panniculus adiposus. While this condition obtains in the globular variety and over the most prominent part of the tumor, in the irregular forms a portion of the hernia may be covered by layers of fat of considerable thickness. The contents consist at first of omentum or of a portion of transverse colon; later of large and small intestine and omentum, sometimes of stomach, even of uterus and cecum. The omentum becomes adherent at an early date, rendering the hernia irreducible and favoring the escape of intestine; the latter may long remain nonadherent. But the thin coverings of the hernia and the continued mechanical insults from the pressure of clothing often set up attacks of adhesive peritonitis, so that in old cases we often find the large and small intestine and omentum tied up in an almost inextricable mass. The intestine may perforate the omentum, thus favoring strangulation. The entrance of gut into lateral pockets in the sac with narrow necks is another not infrequent event; sometimes such pockets become entirely closed off, and remain as cyst-like cavities filled with fluid. We often find irregular septa of fibrous tissue passing from one side to the other of the sac, dividing its cavity into a num-

ber of large loculi. Broad adhesions are common in these cases between hernial contents and sac, notably in front, where the coverings are thinned out, sometimes as thin as blotting paper; through the thinned-out coverings the contours of intestinal coils are usually plainly visible. The deeper portions of the hernia near the ring are usually found nonadherent, or isolated adhesions may be found extending to the ring and even well within the abdomen; such adhesions involve omentum and the lining of the sac chiefly. On account of the thinned-out condition of the skin and consequent feeble nourishment, the cutaneous surface often becomes excoriated, inflamed, and sometimes ulcerated.

The *symptoms* produced depend upon the size of the hernia, the interference with the function of the bowel by adhesions—i. e., digestive disturbances, colicky pains, constipation, etc., and, further, upon true obstructive symptoms, and finally upon strangulation due to the same causes. Many of these patients are large, fat, flabby women with extremely relaxed abdominal walls; the symptoms of enteroptosis are common—draggings, pains, neurasthenia, etc. Though strangulation is not more common than in other forms of hernia, yet it is more dangerous and fatal; thus, Gibson (*Annals of Surgery*, October, 1900) found the mortality from gangrenous umbilical hernia, 67 per cent; inguinal hernia, 26 per cent; femoral hernia, 37 per cent in the operated cases. The diagnosis of large umbilical hernia can be made on inspection. Reducibility or irreducibility, the size of the ring, diastasis of the recti, are made out by palpation. Obstruction and strangulation give the ordinary signs and symptoms. In fat women with small beginning umbilical herniæ no visible tumor may be present. By deep pressure with the forefinger introduced into the umbilicus, the patient lying down, it is usually possible to feel the edges of the ring. If the sac is occupied by a small piece of omentum or bowel, the characteristic sense of a string or tab of omentum slipping back into the belly or the rounded, elastic feel of a bit of bowel reduced with a gurgle or a sort of pop, establish the diagnosis. Impulse on coughing can be felt when the patient stands erect.

(N. B.—In all cases of reducible hernia, when the signs are doubtful and the hernia refuses to reappear upon coughing, straining, etc., repeated examinations at intervals should be made to establish the diagnosis.)

While these hernia remain reducible they can usually be retained and prevented from growing larger by a carefully constructed cushion or pad and a *broad abdominal belt*, unless the patient is enormously stout. When irreducible the arrangement of a suitable apparatus is sometimes very difficult. Radical operation may be done if the hernia is not too large and the general condition of the patient good. Many operations have been devised. The most successful consist in overlapping the abdominal wall at the site of the hernia from above downward (Blake, Mayo).

Ventral Herniæ.—Protrusions through the abdominal wall other than umbilical herniæ occur in a variety of situations—central, lateral, and posterior.

They may occur in situations where the arrangement of the muscular and fascial layers of the belly wall produce a point of diminished resistance, or as the result of wounds and surgical operations upon the belly, notably when an infected penetrating wound has healed by granulation, and when nerves supplying the muscles have been cut, sometimes as the result of subcutaneous lacerations of the muscles and fasciæ. Subserous lipomata which insinuate themselves through the wall of the belly are a frequent cause. In these cases the hernia may follow the path of the blood-vesels, notably in the mammillary line.

Herniæ in the Linea Alba.—These may occur in the epigastrium (see Epigastric Hernia, Diseases of the Abdominal Wall) or below the umbilicus. Both are more frequent in males, four to one, and occur for the most part during adult life. The epigastric herniæ, though of small size, may, as described, cause very marked symptoms. The herniæ below the umbilicus may attain a considerable size. They are situated usually within two inches of the umbilicus. The diagnosis of the latter form offers no great difficulties upon careful examination.

Diastasis of the Recti Muscles.—Diastasis of the recti muscles occurs in two forms: (1) Above the umbilicus in children, in which case the weakness and bulging usually disappear as the child grows up, though a small, isolated hernia sometimes remains. (2) Below the umbilicus in adult women who have borne several children. The entire linea alba may also be affected. The diagnosis is simple. When the woman stands up the recti separate and a distinct bulging occurs between their borders; in marked cases the tissues between the muscles may be so thinned out that a great part of the abdominal contents protrudes through the muscles. Upon lying down the bulging disappears. Palpation permits one to feel a distinct cleft between the muscular borders through which the hand may be passed, the lax abdominal wall invaginated, and the contents of the belly palpated with great ease. If the patient be directed to raise her head the borders of the recti spring into bold relief. At the same time the muscular borders may be felt firmly closing upon the hand.

Herniæ in the Linea Semilunaris.—Herniæ occasionally occur along the outer border of the rectus muscle. Only a small number of such cases have been reported. The hernia may penetrate the transversalis muscle merely, and then spread between the layers of the abdominal wall—"masked hernia." In most cases these herniæ have occurred in elderly women who have borne many children. The diagnosis may be difficult when the hernia is small and covered by a thick layer of fat. The symptoms may resemble those of epigastric hernia. There may be a fixed point of pain and tenderness. The symptoms usually disappear when the patient lies down. Strangulation of such herniæ has occurred. A very few cases of herniæ in the lineæ transversæ have been reported. Macready reported seven cases observed by the London Truss Society in sixteen years.

Lumbar Hernia.—This form of hernia occurs in the lumbar region, for the most part in elderly adults whose tissues are feebly nourished and flabby, less often as a congenital condition in infants. The site of the protrusion appears to vary in different cases. Two lumbar triangles are described: one, the larger, having its base directed upward, corresponding to the twelfth rib; the other, smaller, its base directed downward, corresponding to the crest of the ilium. The upper and larger triangle is bounded internally by the sacrolumbalis, outwardly by the posterior margin of the internal oblique muscle. The apex of the triangle is directed downward to the crest of the ilium. The lower small triangle lies between the free border of the latissimus dorsi muscle and the external oblique muscle. The apex of the smaller triangle is at its upper part, and lies at the junction of these two muscles. The smaller triangle is known as the triangle of Petit; the upper and larger triangle is covered for the most part by the latissimus dorsi muscle. The herniæ may apparently occur in either of these two situations. Special forms also occur, irrespective of anatomical boundaries, as the result of accidental trauma, of surgical operations in the lumbar region, and of disease of the bones or of the soft parts, with the production of bony necrosis or of destruction of the soft parts by suppuration. In adults the cause of these herniæ appears to be largely weakening of the tissues from advanced age, from wasting conditions, from repeated pregnancies, and, as stated, from injury or disease. The herniæ then appear either near the tip of the eleventh or twelfth rib or just above the crest of the ilium at the outer border of the latissimus dorsi muscle. In the congenital cases, the hernia is due to an imperfect development of the muscular layers of the posterior abdominal wall. In a case of Dr. Charles N. Dowd's, the hernia occurred in a little child as a congenital condition, and was operated upon at the age of two years and a half; the vermiform appendix and a portion of the cecum formed the contents of the sac. In a congenital case observed by Wyss the hernia made its appearance through an orifice in the external and internal oblique and the transversalis muscle; the lower ribs were also congenitally absent in this case. Twenty-six cases of lumbar herniæ were collected by Macready. Grange collected, in 1895, 45 cases; in 20 of these the point of origin of the hernia was determined, 9 escaped through Petit's triangle, 2 through the upper and larger triangle, 3 through a congenital muscular defect, 1 a defect of the crest of the ilium, 1 occurred as the result of necrosis of the bone, 1 through a scar, and 3 through canals proceeding along the course of the muscles and nerves of the region. In the cases collected by Grange the left side was affected a little more often than the right; in 2 cases the hernia occurred on both sides; 18 were males, the rest females; among the latter, 5 were congenital (Graser). When these herniæ are well marked no difficulties exist in the diagnosis; still, numerous errors have been made. Such herniæ have been mistaken for lipomata, for cold abscesses, and for other lesions.

Obturator Hernia—Herniæ of the Foramen Ovale.—Something over 200 of these cases have been collected and published. The hernia occurs through the

obturator canal, which exists at the internal anterior portion of the obturator membrane for the passage of the obturator vessels and nerve. These structures, as a rule, lie behind and to the outer side of the sac. Among the cases collected by Berger, 118 were women and 18 were men. The hernia is not infrequently bilateral, usually occurs in old women, and is often associated with other forms of hernia, notably femoral hernia. A variety of structures have been found in these herniæ; most often small intestine and partial hernia is not uncommon. The vermiform appendix, the omentum, the bladder, the ovary, the tube, the uterus, have all been in rare cases found in the sac. In most cases the hernia appears at the upper border of the obturator externus muscle—that is to say, just behind the pubic bone. It is thus covered by the pectineus muscle, and must reach a considerable size before it produces a visible or even a palpable tumor. It may sometimes be felt in the same region as a femoral hernia, but, of course, the palpation must be deep. The finger should be pressed inward, upward, and backward, internal to the common femoral artery and external to the border of the adductor longus muscle. Indeed, the diagnosis of these herniæ has scarcely ever been made until after strangulation has occurred. In order to make this examination most satisfactorily the thigh should be adducted, rotated outward, and flexed. Bimanual examination through the rectum or the vagina has occasionally permitted the surgeon to feel the neck of the sac inside the pelvis. These herniæ very seldom attain a large size, one hernia as large as an orange having been observed. The symptoms of obturator herniæ may be quite characteristic, provided only that the surgeon's attention is directed to the possibility

FIG. 58.—VENTRAL HERNIA THROUGH THE SCAR OF AN ABDOMINAL INCISION. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

of this condition. As stated, nearly all these cases have been diagnosticated only after strangulation had occurred. If a tumor is palpable in the groin, localized pain and tenderness on deep pressure will always be elicited. There are quite definite symptoms referable to the pressure of the hernia upon the obturator nerve: Pain down the inner side of the thigh, referred especially to the vicinity of the knee-joint, occasionally diminution of sensibility in the skin supplied by the nerve, and in some cases disturbance of function in the muscles. The patients keep the thigh flexed and abducted, adduction being impossible. Any motion increases the pain. These disturbances of function in the obturator nerve have been observed in about half the cases. In addition to these localized symptoms there are the symptoms of strangulation of the bowel. In many of the observed cases the diagnosis has been made of internal strangulation, the presence of the hernia remaining unsuspected until the time of operation or at the autopsy. Obturator hernia is one of those forms not infrequently associated with femoral and inguinal hernia, and in a number of instances the symptoms have been referred not to the true cause of obstruction, but to an inguinal or femoral hernia which was not strangulated.

Ischiatic Hernia.—A very few cases only of ischiatic hernia have been described. The hernia may escape through the sacrosciatic foramen above, or, more rarely, below the pyriformis muscle. One or more cases have been observed in which the hernia escaped through the lesser sacrosciatic foramen. Macready was able to collect seventeen cases of ischiatic hernia. The sexes appeared to be about equally affected. Nearly half the cases were observed during infancy or at birth. The contents of the sac have been in most of the cases the intestine or the omentum, in a few a portion of the bladder or the ovary. Inasmuch as these herniæ are for the most part covered by the gluteus maximus muscle the diagnosis is extremely difficult, and must depend upon a localized point of pain and tenderness below the muscle in the vicinity of the sacrosciatic foramen and upon the symptoms of strangulation, if such are present. In a few of the cases the hernia has descended into the thigh and formed a visible or palpable tumor. A mistake in diagnosis is likely to occur; such a hernia might well be taken for cystic tumors, abscesses, lipomata, hematomata, or other similar conditions. In case the diagnosis is made, the operation should be done through a free incision under the control of the eye, on account of the vicinity of important blood-vessels and nerves.

Traumatic Ventral Hernia.—As the result of accidental wounds or of surgical operations the abdominal wall may be weakened, so that an abdominal protrusion takes place. At the present time, with more accurate methods of suturing and consequently the approximation of the individual layers, better healing is obtained now than formerly after abdominal operations, and the occurrence of ventral hernia is rather less frequent. The old method of through-and-through suture of the abdominal wall was, no doubt, responsible for many herniæ. At the present time, unless we are obliged to leave the abdominal wound widely open for drainage on account of infection, we rarely

expect patients to develop a ventral hernia, if primary union is obtained in the wound, if the patients' tissues are reasonably firm, if they are kept in bed a sufficient length of time after operation, and if in those instances where it seems wise they wear an abdominal belt or supporter during the year following the abdominal section. Formerly the operation for appendicitis when done by complete division of the muscular fibers resulted in ventral hernia in a good many cases. This was partly due to imperfect union between the muscular structures and partly to division of the nerves and paralysis and atrophy of the muscles. The entire right lower quadrant of the abdomen was affected; the abdominal wall seriously weakened, so that these patients were obliged to wear an abdominal support for an indefinite time. At present in America it is the habit of most surgeons to do nearly all of their operations for appendicitis, whether acute or during the interval, through McBurney's intermuscular incision. The abdominal wall thus remains very nearly as strong as before the operation was done, and hernia, if it occurs at all, is extremely rare. Herniæ following an incision in the median line are less common than after lateral incisions. They are still occasionally observed, and may involve the entire length of the scar, or there may be several small protrusions here and there, due to imperfect union of the fascial layers. Incisions in the line below the ribs for the purpose of operating upon or removing the kidney have only very rarely been followed by hernia. A few cases have been reported in the city of New York during the past ten years. The recognition of these herniæ is entirely simple, and requires no separate description. They are best treated by operation, sometimes rather difficult on account of intra-abdominal adhesions of the intestine to the scar, and are to be avoided by careful methods of suture, by keeping the patient in bed a suitable length of time, and by advising him, when the occurrence of hernia seems possible, to wear for a certain length of time a carefully fitted abdominal support with a well-constructed pad to support the scar. (See also Injuries of Nerves, vol. iii.)

Herniæ through the Floor of the Pelvis.—These heriæ are extremely rare, and so few of them have occurred that accurate description of the various situations in which they may take place is hardly possible. They nearly always occur in adults, more often in women than in men. Macready was able to collect forty cases, about three fourths of which were among women. They appear in the ischiorectal region, in the vagina, or the labia majora near the perineum. To these last the name "pudendal" hernia has been applied. Among women Winckel distinguished three varieties of perineal hernia: (1) The anterior form, in which the hernia takes place between the constrictor cunni and the ischiocavernous muscle. (2) Between the constrictor cunni and the deep transversus perinei muscle. (3) Posterior perineal hernia, between the transversus perinei and the gluteus maximus muscle. The diagnosis of these herniæ is usually not difficult unless they present in the vagina. Their contents is nearly always intestine; they are, therefore, tympanitic on percussion, and the ordinary signs occur accompanying the reduction of intestine. They

grow smaller when the patient lies down and larger in the erect posture, show an impulse on coughing, etc. Those which project into the vagina may be mistaken for any other lesion which forms a projection into this canal—uterine polypus, cystocele, abscess, prolapse of the rectum into the vagina, etc. They may sometimes be controlled, when external, by some form of supporting pad or truss, or by a pessary when they project into the vagina. When they give rise to serious symptoms, they are best treated by an abdominal operation. The symptoms produced vary in different cases, and consist of pain, interference with the function of the bowel, and other symptoms, such as have already been described under other forms of hernia.

Prolapse of the rectum, including the peritoneal pouches, may properly be included among the herniæ. They have already been described under Diseases of the Rectum.

(For Diaphragmatic Hernia, see Injuries and Diseases of the Diaphragm.)

CHAPTER X

THE KIDNEY AND URETER, TOPOGRAPHICAL ANATOMY AND METHODS OF EXAMINATION

ANATOMICAL REMARKS

(Adapted from Merkel, Joessel, Woolsey, and Schede)

THE kidneys lie behind the peritoneum deeply placed on either side of the spine, so that under normal conditions it is difficult or impossible to feel either kidney by ordinary methods of palpation, except sometimes the lower pole of the right kidney. The ability of the individual surgeon to palpate the kidneys will vary a good deal with his skill and experience, and, of course, also with the physical conformation of the patient, whether stout or lean, firm or flabby. A vertical line drawn through the middle of Poupart's ligament cuts the kidney lengthwise, so that one third of the organ lies to the outside and two thirds to the inner side of this line. The line joining the lowest points of the tenth costal cartilages roughly corresponds to the lower border of the kidneys. In women and children the kidneys are ordinarily a little lower than in males, and may extend as low as the level of the crest of the ilium. The right kidney is usually about half an inch lower than the left. The position of the kidneys corresponds more or less to the level of the last dorsal and first two or three lumbar vertebræ. The left kidney extends from the lower border of the eleventh dorsal spine to a little below the second lumbar spine. The position of the kidney may be indicated, according to Morris, posteriorly by a parallelogram, whose upper and lower limits are lines drawn horizontally from the lower end of the eleventh dorsal spine above, and through the lower border of the second lumbar spine below; that is to say, about four or four inches and a half in vertical measurement; while the sides of the parallelogram are indicated by lines drawn vertically an inch from the spine and three inches and three quarters from the spine, representing the inner and outer borders of the kidney respectively. The twelfth rib crosses the kidney obliquely from within outward and from above downward, so that about one third or more of the organ is above it, and therefore beneath the wall of the thorax. The eleventh rib overlaps the upper pole of the left kidney, and the tips of the transverse processes of the first and second lumbar vertebræ reach to or slightly overlap the inner border of both kidneys. The lower end of

the right kidney is on the average an inch and a half above the crest of the ilium posteriorly, and about the same distance above the level of the umbilicus in front. The hilum is about two inches from the median line and opposite the spine of the first lumbar vertebra. The long axis of the kidneys is directed from above downward and outward, so that the lower pole of the kidney is from one half to an inch farther removed from the middle line than the upper pole. The inner border of the right kidney lies close to the vena cava. The inner border of the left kidney is removed about an inch from the aorta. The kidneys descend half an inch or more during inspiration, and are pushed downward by fluid accumulations above the diaphragm. The kidneys are lower in the erect posture or the sitting posture than when the individual lies down. This fact may be taken advantage of in some cases when endeavoring to palpate the kidney.

FIG. 59.—PROLAPSE CONTAINING UTERUS, BLADDER, RECTUM, AND DOUGLAS'S POUCH FILLED WITH SMALL INTESTINES. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Relations of the Kidney.—The kidneys lie upon the surface of the diaphragm above, the quadratus lumborum, transversalis, and outer border of the psoas below, the fascia of the muscles intervening. The kidney is in contact with the diaphragm over a larger area on the left than on the right side, owing to the higher position of the left kidney. These relations of the kidneys to the diaphragm are quite important, surgically and pathologically, not only in reference to wounds, but also in reference to suppurative conditions. Above the diaphragm lies the pleura, whose lower limit extends in a nearly horizontal direction from the lower border of the twelfth dorsal vertebra, and meets the twelfth rib about three inches and a half from the middle line and the eleventh rib about two inches farther out. Hence it is not surprising that abscesses in or around the kidney may perforate into the pleura, and, further, that in operations upon the kidney there is a certain risk of opening the pleura if the incision is made at too high a level. This is especially true in cases where the twelfth rib is absent, and in such cases operations upon the kidney have opened the pleura, sometimes with fatal results. An incision for exposing the kidney, then, should always lie below the border of the twelfth rib.

In regard to the dangers of wounding the pleura in operations upon the kidney, it is to be remembered that the development of the twelfth rib is by no means regular. In a certain number of cases the rib is so short as to escape

observation; the surgeon might then mistake the eleventh rib for the twelfth, and open the pleura. In other cases the twelfth rib is absent; such absence may be unilateral or bilateral; the corresponding vertebra may also be absent in these cases. Holl examined 120 cases; among these the twelfth rib was absent 6 times, in three males on both sides. Among 72 cases, in 20 the rib was so short that it could be neither seen nor felt on external examination. It is therefore the duty of the surgeon before operating close to the lower border of the ribs for the exposure of the kidney to feel and identify the free ends of the last two ribs. These being felt, the situation is entirely clear.

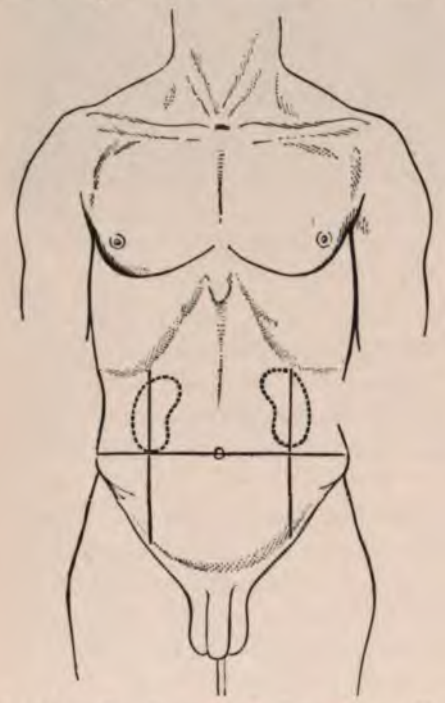

FIG. 60*a*.—THE RELATIVE POSITION OF THE KIDNEY TO THE FRONT SURFACE OF THE ABDOMEN. (After Henry Morris.)

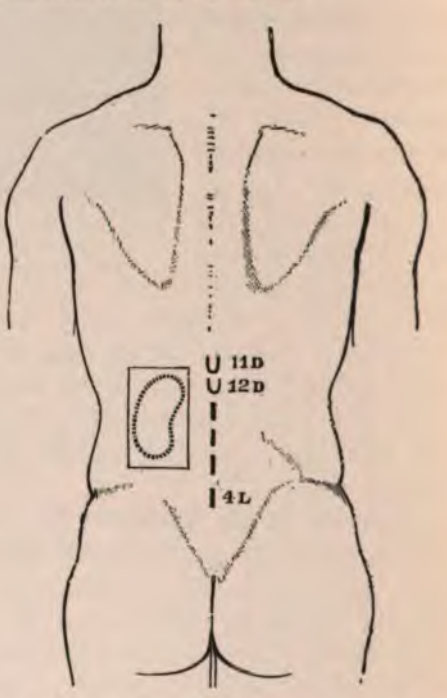

FIG. 60*b*.—RELATIVE POSITION OF THE KIDNEYS TO THE POSTERIOR SURFACE OF THE BODY. (After Henry Morris.)

Relations of the Kidney in Front.—The relations of the two kidneys are different. The right kidney is in a relation in front with the liver, with the ascending colon in its lower half, and the second portion of the duodenum along its inner border. The left kidney is in relation in front with the stomach above over its upper third, the splenic vessels and the pancreas in its middle third, and the descending colon in the outer part of its lower third. Along the upper half of the outer border lies the spleen (Woolsey).

Relations of the Kidney to the Peritoneum.—The above-mentioned viscera, with the exception of the liver and the stomach, separate the kidney from the peritoneum. In its relations with these two organs the peritoneum intervenes. The area of kidney surface covered by peritoneum is greater upon the right

side. The peritoneum is readily stripped from the front of the kidney, unless this membrane be adherent to the kidney capsule on account of inflammatory or malignant infiltration, and in approaching the kidney by the common or retroperitoneal route we take advantage of this circumstance to push the peritoneum away from the front of the kidney, and thus expose it. As a matter of practical experience it happens that wounds and ruptures of the kidney in a large percentage of the cases do not wound the peritoneum. This is true to an extent greater than that of most of the other abdominal organs.

The Coverings and the Fixation of the Kidney.—The kidney substance is inclosed in a thin, translucent, fibrous capsule, the so-called tunica propria of the kidney. While this fibrous capsule clings everywhere to the substance of the kidney closely, in health it is very easily stripped away from the underlying parenchyma. At the internal border of the kidney this capsule is continued as a thin fibrous sheath for the vessels and nerves extending to the vena cava and to the aorta, and, on the other hand, is prolonged into the hilum of the organ, at least as far as the borders of the papillæ of the kidney and the calices. Another leaflet, thicker and firmer, passes outward behind the renal vessels and in front of the ureter to merge into the fibrous sheath of the aorta, and a part passes also to the lumbar portion of the diaphragm. This structure is supposed to have a supporting influence upon the kidney, and was called by English the suspensory ligament of the kidney. Outside the tunica propria the kidney is surrounded by a fatty layer, the so-called fatty capsule of the kidney, which is derived from the subperitoneal connective tissues. The kidney thus is embedded in a layer of fat, usually of considerable thickness, and is no doubt thus protected to a great extent from external injuries. The fat is absent or scanty at birth, and is scarcely noticeable until after the tenth year of life. The fat is most abundant upon the convex border of the kidney at the lower pole, on the posterior surface, and at the hilum. When adult individuals become notably emaciated, this fatty layer may be largely or completely absorbed. The kidney, having lost this firm padding or support, may become more or less movable. Abscesses which form in the vicinity of the kidney spread readily in the loose fatty capsule surrounding it, and may burrow in a number of directions. As already noted, they not infrequently perforate the diaphragm and infect the pleura. They may form abscesses in the back below the ribs if they penetrate into the intestine; the colon and the duodenum, on account of their close relations with the kidney, are usually the portions of the bowel perforated. The peritoneal cavity is very rarely infected.

Certain fascial structures have been recognized and described by different observers as having an important bearing upon the support and fixation of the kidney. Thus, Gerota described a layer of fascia, called by him fascia prerenalis; it is more markedly and more regularly developed upon the left side. It passes from the anterior surface of the kidney to unite with the retroperitoneal connective tissue behind the descending mesocolon. It passes on the

other side to the surface of the pancreas, and still farther to the anterior surface of the vessels lying in front of the spinal column. The layers of fascia lying in front of and behind the kidney unite along the convex border, and at the upper pole of the organ; they are, of course, separate at the internal border. At the lower pole, also, they remain separate, inclosing between them the fatty capsule; they have been designated *the renal fascia.* Prolongations of these layers pass to the diaphragm, to the muscular sheaths of the psoas, the quadratus lumborum muscle, and a portion of them pass between the muscular bundles, and are attached to the periosteum of the vertebral column. These layers of fascia are believed to afford important support to the kidney. At best, however, the kidney remains but a feebly supported organ. Inasmuch as the kidney is also held in place to a considerable extent by intra-abdominal pressure, it is easy to understand that movable kidney not infrequently follows relaxation of the abdominal walls from pregnancy, ascites, the removal of large abdominal tumors, etc. The kidney becomes movable from a variety of causes other than these, such as external violence, the downward pressure exercised by the liver, notably as the result of tight lacing, depression of the diaphragm from pleural exudates, traction by the ureter, the colon, or the duodenum, and also by increased size of the kidney itself. On account of the presence of the liver, movable kidney is much more common upon the right than upon the left side—namely, in nine tenths of all cases—and it is, moreover, far more common in women than in men. (See Movable Kidney.) The excursions of a movable kidney are limited by the length of its blood-vessels. In what is known as true floating kidney, movable kidney of the third degree (see Diagnosis of Tumors of the Abdomen), the vessels are very long, and the kidney receives sometimes a nearly complete peritoneal investment, so that one may speak of a mesonephron.

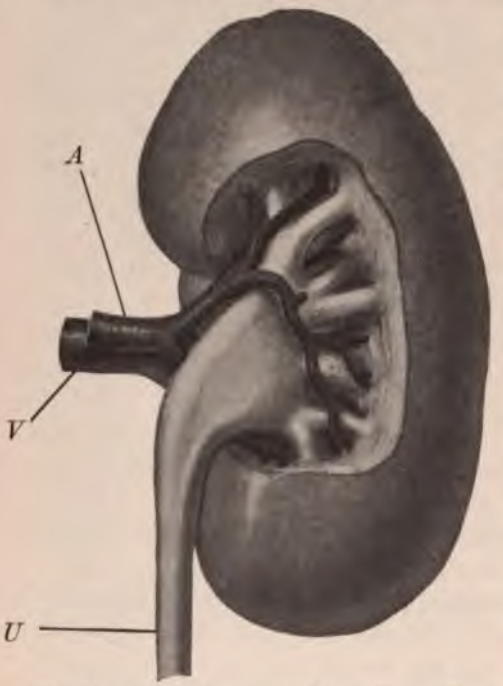

FIG. 61.—THE RELATIONS OF RENAL BLOOD-VESSELS TO THE URETER, CALYCES, AND HILUM OF THE KIDNEY. (Watson, after Spalteholz.)

The Hilum of the Kidney.—The *hilum* of the kidney looks forward and inward and slightly downward. The relations of the structures entering and emerging at the hilum, or rather at the sinus of the kidney, as it is called, are the vein in front, the artery behind it, sometimes at a little higher level, and the pelvis of the ureter behind and below.

The Ureter.—The ureters are about a foot long in the male and a fifth of an inch in diameter; that is to say, about the size of a goose quill. Their caliber is, however, somewhat variable; spindle-shaped enlargements occur here and there, and a slight constriction is said regularly to be present about two inches below the kidney. My experience in taking X-ray pictures of kidney stones leads me to believe that calculi in the ureter are frequently stopped at this point. The ureters are, however, capable of very great distention, provided the distending force acts gradually; thus it is possible to find the ureter in certain cases as large as a man's thumb or even as large as the small intestine. The ureters begin above in a funnel-shaped enlargement, known as the pelvis, which passes out behind the blood-vessels through the sinus, and ends at the lower pole of the kidney in the ureter. Extreme distention of the ureter is usually observed above an impacted stone which closes the lumen of the canal intermittently, sometimes acting like a ball valve. If the ureter be suddenly, completely, and permanently closed, dilatation of the ureter does not take place; the kidney undergoes atrophy. At its lower end the ureter passes obliquely through the bladder wall downward and inward, and the last half or three quarters of an inch of the ureter are included in the wall of the bladder, the muscles of the bladder wall acting as a valve to prevent the reflux of urine from the bladder back into the ureter, no matter how greatly the bladder may be distended. A sphincter action is also created by abundant muscular fibers belonging to the ureter itself and surrounding its lower end. The course of the ureter from the kidney to the bladder lies behind the peritoneum, to which, for the most part, the ureter is quite firmly attached, and passes downward and inward upon the surface of the psoas major muscle; the spermatic artery crosses the ureter at an acute angle, the artery lying in front. Farther downward the ureter crosses the anterior surface of the common iliac vessels, usually just before their division into internal and external iliac. In a few cases the ureter crosses not the common but the external iliac. The right ureter is covered by the ileum, the left by the sigmoid flexure of the

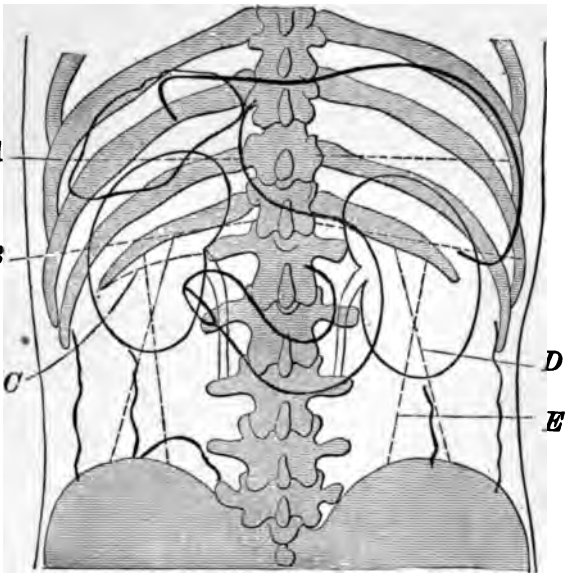

FIG. 62.—OUTLINE OF THE ABDOMINAL VISCERA FROM BEHIND, SHOWING THEIR RELATION TO ONE ANOTHER. (After Merkel.) *A*. Lower limits of lung. *B*. Lower limit of pleura. *C*. Lower border of diaphragm. *D*. External border of erector spinæ muscle. *E*. External border of quadratus lumborum muscle.

colon. The relations of the ureters necessarily differ in the male and in the female. In the male they lie in the parietal attachment of the posterior false ligament of the bladder, running forward and inward they reach the bladder about an inch and a half apart and about an inch and a half behind the prostate. In the female they lie in the base of the broad ligament three fifths of an inch external to the cervix uteri on either side. Here they are crossed in front by the uterine arteries and are surrounded by the uterine plexus of veins. They next cross obliquely the upper third of the vagina, passing forward from the lateral wall of the vagina, and pierce the bladder opposite the middle of the anterior vaginal wall. This relation is sometimes important from a diagnostic as well as from a pathological point of view, since stone impacted in the ureter of the female near its lower end may sometimes be palpated through the anterior vaginal wall, and cancer of the cervix not infrequently involves the ureter, and great care is necessary, when operating upon cancer of the uterus (hysterectomy), to avoid injuring the ureter. In bad cases it is wise to carefully dissect out the ureter, beginning above in the healthy portion and carefully following the ureter down to and beyond the cervix. In this way it is sometimes possible to save the ureter and the kidney, when, if the surgeon failed to use this care, the ureter might be cut, so that the kidney upon that side would be placed in jeopardy, and might have to be removed.

FIG. 63.—X-RAY PICTURE OF A STYLETTED CATHETER PASSED UP THE URETER BY DR. F. T. BROWN. X-ray by the author. (1900.)

The following data in regard to the topographical anatomy of the ureters are adapted from Schede: (1) The junction of the pelvis of the ureter with

the ureter proper may be determined by the point of intersection of two lines. The first line is at the level of the last rib and horizontal. The second line is vertical, parallel with the middle line of the body, passing through the junction of the outer two thirds with the inner one third of Poupart's ligament; 6 cm. below the point of intersection of these two lines is the junction of the pelvis with the ureter. (2) The middle point of that portion of the ureter lying above the true pelvis lies halfway the distance from the tip of the ensiform cartilage to the upper border of the symphysis pubis, and is removed from the middle line, according to the size of the individual, from 3 to 4 cm. (3) The place where the ureter passes into the true pelvis is determined in the following manner: A line joining the anterior superior spines of the ilia is divided into thirds. The point of junction of the middle with the outer thirds on either side indicates the position of the ureter. They best are palpated a little above this point. A procedure sometimes valuable in determining the presence of and the course of the ureter was used by me in the year 1900. A styletted ureteral catheter was passed by Dr. F. T. Brown up the ureter as far as the renal pelvis. An X-ray picture was then taken of the patient's body, showing very plainly the wire, and consequently the direction and situation of the ureter (see Fig. 63). In cases where the presence of or the patency of the ureter was doubtful, or in cases where but a single kidney existed giving off two ureters, this procedure might be extremely valuable, and would probably be applicable to any case in which a ureteral catheter could

Fig. 64.—Styletted Ureteral Catheters in the Pelves of the Kidneys. Case in the author's service at the New York Hospital. The patient was a man who had suffered from symptoms suggesting renal calculus in the left kidney. He stated that he had been told as the result of an operation in another city that he had but one kidney, or rather a horseshoe kidney with a high degree of fusion. The X-ray picture as taken demonstrated the presence of two normally placed kidneys. The operation disclosed no stone in the kidney but the presence of a sharp kink in the upper portion of the ureter caused by a mass of scar tissue. The author removed the scar tissue and the patient was relieved of his symptoms. In the original radiograph the stylets show plainly throughout their course and the kink in the ureter can be plainly seen.

be introduced at all. Illyès used this method also in order to determine whether a tumor in the left hypochondrium was a tumor of the kidney or an enlarged spleen. A description of the varieties and abnormalities of the ureters will be found under Congenital Defects of the Kidney and Ureter.

The Suprarenal Bodies or Adrenals.—The suprarenal bodies are two ductless glands, one of which rests upon the upper end of each kidney, projecting slightly on to its anterior surface and inner border. They are separated from the kidney by the fatty capsule of that organ. They are proportionately larger in infants than in adults, undergo atrophy during advanced life, sometimes become the seat of new growths, and occasionally form tumors, the tissue of which does not materially differ from that of the normal adrenal body; but such tumors may grow to a large size, may form metastases in various parts of the body, more commonly in the vicinity of the kidney, but occasionally in distant parts, the leg, for example. (See Hypernephroma.) The disease known as Addison's disease is attended by a degeneration of the adrenal bodies. They rest upon the eleventh and twelfth ribs, and an interval of from two to two inches and a half separates the one from the other. These bodies, as such, cannot be said at present to have any very important surgical relations, since they are rarely operated upon unless they become the seat of a tumor of considerable size, and in operations upon the kidney they are rarely factors of importance. The blood-vessels of the suprarenal bodies, notably of the left side, communicate to a greater or less extent with those of the kidney.

The Blood-vessels of the Kidney.—The renal arteries are unusually large for the size of the viscus which they supply—namely, about the size of the brachial artery. They are branches of the abdominal aorta, given off at right angles, and it is to be borne in mind that the right renal vein and left renal artery are shorter than their accompanying vessels, and in some cases of nephrectomy upon the right side the shortness of the right renal vein may cause the operator considerable difficulty. Before entering the hilum of the kidney the renal arteries divide commonly into four branches, of which two supply the anterior portion and two the posterior portion of the organ. The posterior surface of the renal pelvis is free from blood-vessels of any considerable size. According to Jössel, the renal artery usually gives off four branches, two anterior, one superior, and one posterior. Of the two anterior branches, one passes to the middle, the other to the lower portion of the anterior half of the kidney; the upper branch supplies the upper pole, the posterior the lower two thirds of the posterior portion of the kidney. Anomalies of the renal artery are extremely common. Thus in 15 cases Zondek found in 9 one renal artery, in 5 two, and in 1 three arteries. The additional branches may pass to the hilum, to the anterior surface, or to either pole of the kidney, most often to the lower pole. The blood supply of the fatty capsule of the kidney is given off from the renal artery itself or from one of its branches, and may pass directly into the capsule or be given off from the surface of the kidney itself. A further blood supply arises from the first lumbar artery directly from the aorta,

The study of corrosion preparations of the arterial supply of the kidney is interesting. The principal branches of the renal artery each supply an area of kidney substance separate and distinct from one another. These areas may be divided roughly into an anterior and posterior group. In the cortex of the kidney there are no free anastomoses between the branches of these vessels along a line occupying the middle third of the convex border of the kidney and slightly posterior to the vertical midline of this border. Thus this portion of the cortex may be incised vertically without much bleeding. Unfortunately, this relatively anemic zone does not extend to the hilum. The vessels at the level of the bases of the pyramids cross the midline of the organ freely, so that no incision through the cortex which opens into the pelvis can be made without free hemorrhage (see Fig. 65). Corrosion preparation of the arteries of the kidneys. The peculiar distribution of the renal artery explains the frequent occurrence of embolic processes, whether pyogenic or tuberculous, limited to some circumscribed portion of the kidney structure. Furthermore, the irregular manner in which the renal artery gives off its branches accounts for the occurrence of hemorrhage in nephrectomy after the operator has included in his ligatures what appears to him to be the entire arterial supply of the kidney.

FIG. 65. — CORROSION PREPARATION OF THE BLOOD-VESSELS, CALYCES, AND UPPER PORTION OF THE URETER IN THE HUMAN KIDNEY, SHOWING THE ABUNDANT VESSELS CROSSING THE MIDDLE LINE OF THE ORGAN. Only the larger vessels are injected. (Anatomical Laboratory of the College of Physicians and Surgeons of Columbia University, kindness of Prof. G. S. Huntington.)

The Renal Veins.—The renal veins leave the kidney at a level slightly below the artery and empty into the vena cava. The lymph vessels of the kidney empty into the lumbar glands.

NERVES OF THE KIDNEY.—The nerves of the kidney come from the renal plexus derived from the solar and aortic plexuses and the lesser splanchnic nerves. The communication of the renal and spermatic plexuses accounts for the radiation of the pain of renal colic to the testis, etc. The nausea, vomiting, and other symptoms indicating irritation of the intestine, and the rectal and vesical tenesmus sometimes noted in renal colic, are accounted for by the relation of the nerves of the kidney with the sympathetic ganglia supplying the intestines and bladder respectively. From a similar association between the renal plexus and the lumbar nerves pain may be felt in the latter from

renal calculus, and sometimes disease of the lumbar vertebræ may be mistaken for renal colic, or, on the other hand, kidney stone may lead to the diagnosis of disease of the vertebræ, as I have observed in a considerable number of cases. The vasomotor center for the kidney lies in the floor of the fourth ventricle. Irritation of this center causes contraction of the vessels of the kidney and oliguria; paralysis, on the other hand, causes dilatation of the vessels and polyuria. When the neighboring center for the liver is involved at the same time there will be, in addition to an increased quantity of urine, the presence of sugar in the urine or "traumatic diabetes." On account of the intimate relations of the nerves of the sympathetic system of the two sides, irritation of one kidney may lead to loss of its function, and in a reflex manner to diminution or loss of function in the other kidney. This condition is known as reflex anuria.

METHODS OF EXAMINING THE KIDNEY

I have very little to add to what has already been said in the chapter on the diagnosis of diseases and of tumors of the abdomen in regard to the examination of the kidney by the ordinary methods of inspection, palpation, and percussion. A few additional data may, however, be in place here. From inspection it is rarely possible to see the kidney unless it is greatly increased in size; the characteristic appearances have already been noted. As to the methods of palpation, most of them have already been described, and usually each surgeon will habituate himself to some particular method or methods of examination, and will succeed better in this way than in any other. The lateral position, the patient lying upon his side with his thighs flexed, and the half-reclining position, in which the patient sits about half erect with the knees drawn up and with the head and back thoroughly supported, so as to relax as far as possible the muscles of the abdominal wall, are the two positions which I prefer. The dorsal position is less favorable, notably for the detection of movable kidney, because when a patient with movable kidney lies down, the kidney frequently slips up into its normal position. The position in which the patient sits upon the chair and bends forward, with his arms and head supported, while the surgeon sits behind him or to one side, is also useful. A method of examining tumors of the kidney, called by Guyon "ballottement of the kidney," is also useful. The surgeon places one hand over the tumor in front, and with the other makes repeated sudden and rather forcible pressure in the back in this manner the abdominal hand is sometimes able to make out the size shape, character of the surface and consistence of renal tumors. General anesthesia is a valuable, in some cases an indispensable, aid in palpating tumors of the kidney. The normally placed kidney of well-nourished individuals can rarely be felt. In fact, many surgeons believe that if the kidney can readily be palpated, it is a positive indication of misplacement or disease. This is not true, however, of slender individuals with relaxed abdominal walls. In

these, as has already been noted, it is sometimes possible to feel the kidney, notably the right kidney, quite distinctly. The relations of kidney tumors to the colon have already been noted as well as the differential diagnosis between enlargement of the kidney and other tumors. The value of percussion of the normally placed kidney, if not increased in size, is very slight indeed. It is by no means possible by this means to determine the presence or absence of a kidney in either loin. In a general way, it is rarely wise to introduce an aspirating needle into the kidney for purposes of diagnosis. Exceptions to this rule will be noted in their proper places. The use of an exploratory incision in either hypochondriac region and the introduction of one or more fingers into the peritoneal cavity for the purpose of palpating the kidney has only a very restricted sphere of usefulness. While it is possible in this way to determine with certainty the presence of one or two kidneys, it is by no means possible to tell whether or not such kidneys are healthy, or to distinguish whether one kidney is notably more diseased than the other, in all cases. I have known instances where highly competent surgeons in using this method of diagnosis have committed the most unfortunate errors. The symptoms of kidney disease having been definitely referred to one side of the body palpation through an incision has indicated that one kidney was extensively diseased; palpation of the other kidney has indicated that, as far as could be determined by the sense of touch, the kidney was normal in size, shape, and consistence, and yet, the first kidney having been removed, death has ensued, and it has been found that the remaining kidney was either more diseased than the one removed, or that it was in certain instances entirely without function, containing no kidney substance whatever, existing as a mere cyst without kidney structure or presenting a very advanced stage of tuberculosis or of disseminated pyogenic foci.

A number of other procedures have been tried by various surgeons for determining the condition of the kidneys: Direct palpation through an incision in the middle line of the abdomen permits the surgeon not only to feel the individual kidneys, their size, and other physical qualities, but also to get a more or less incomplete opportunity to inspect the organs *in situ*. A measure now in use by a number of surgeons, notably by the Mayos, in case all ordinary means of examination fail to give a satisfactory result, is to expose the supposedly healthy kidney by an incision in the loin behind the peritoneum, and to determine by inspection, palpation, and other means, if such are necessary, the condition of the organ. If this kidney is found healthy, the wound may be closed and the other kidney extirpated. If, on the other hand, it is distinctly diseased, the case is not suitable for nephrectomy. In cases where catheterization of the ureters is impossible, and where other means have failed, the bladder may be opened above the pubes and the ureteral catheters introduced into the mouths of the ureters under the immediate control of the eye, the bladder being gradually drawn up into the wound for the purpose of bringing the ureteral orifices into view. The ureteral catheters, care-

fully labeled, having been introduced into the mouths of the ureters, the distal extremities of the instruments are drawn out through the urethra, and the bladder wound is closed. This method of examination is very seldom used at the present time.

The proceeding of Pinner has, as far as I am aware, never been practiced to any considerable extent in America. It consists of exposing the kidney by an incision, incising the kidney substance or the posterior surface of the pelvis, and introducing into the ureter a catheter which fits the caliber of the canal tightly. This catheter has no eye at the end. It is introduced into the ureter two or three inches. The ureter, including the end of the catheter, is surrounded by a catgut ligature just tightly enough applied to completely close the canal. The catheter has several small eyes which occupy the renal pelvis, thus permitting the urine from that kidney to escape through the catheter outwardly, so that none of the urine passes into the bladder. The absence of leakage around the catheter may be determined by injecting into its caliber methylene-blue solution. In this way the opposite kidney alone furnishes urine emptied by the normal channels, and the urines of the two kidneys may be compared. At the present time when catheterization of the ureters has been developed to a very accurate and complete method applicable to a large proportion of cases of kidney disease, the method of Pinner has a very restricted field of usefulness.

As already stated, the operation of nephrectomy presupposes a knowledge on the part of the surgeon of the functional condition of each kidney, and while ureteral catheterization is our main dependence in this connection, certain other diagnostic measures are sometimes helpful. In the first place the general question must be answered: Are the two kidneys functionating in a normal manner or to a degree which permits the removal of either of them? The answer to this question may be sought in a variety of ways. In addition to the ordinary chemical and microscopical examination of the urine, we seek to determine whether the kidneys are excreting the physiological decomposition products of albumen, or, what for practical purposes amounts to the same thing, is urea being excreted in sufficient amount to prevent its accumulation in the system? For this purpose we collect the entire quantity of urine passed in twenty-four hours, and determine its content of urea. While the amount of urea excreted varies widely under normal conditions, according to the diet, the habit of life of the individual, and other circumstances, yet in the average case the normal amount may be said to vary from 20 to 35 gm. *per diem*. If this quantity is reduced one half, it is generally believed that the operation of nephrectomy cannot properly be performed, and yet to make the examination valuable it must be repeated a number of times at intervals, because it is found that in cases of nephritis the excretion of urea may be at one time very small, and during another period normal or even in excess of the normal limit.

In order to estimate with certainty the work being done by either kidney it is necessary to catheterize the ureters, and determine the amount of urea

in each specimen. This may be done by the volumetric method of Esbach and Paris. A mixture of urine and alkaline bromid is shaken together in a graduated glass tube, and the volume of liberated nitrogen produced by the decomposition of urea is measured by the volume of fluid displaced by the liberated gas. Reference to tables accompanying the instrument gives the percentage of urea.

It is further to be borne in mind that in a number of septic conditions of a kidney the other kidney may be the seat of a nephritis, which improves, and even disappears after the removal of the more highly diseased organ, with its associated chronic sepsis. Other diagnostic details in reference to the presence of abnormal ingredients in the urine, and the conclusions to be drawn under various conditions, will be dwelt upon more at length in considering the differential diagnosis of the various diseases of the kidney.

Cryoscopy.—Some years ago Dreser, and after him Koranyi, discovered a new method whereby it was believed that many of the difficulties in the diagnosis of surgical diseases of the kidney, especially with reference to the functional activity of one or both organs, and consequently the decision of operability or nonoperability in the given case, might be satisfactorily answered. While the method has aroused much interest, and has been utilized by surgeons all over the world for the past few years, at the present time we have learned that so many practical difficulties occur and so many modifying circumstances in the given case that the conclusions to be drawn are not as definite as was at first believed. The method depends upon the following facts: In the animal body, as well as outside of it, if two fluids are separated by an animal membrane the phenomena of osmosis occur. Such a condition exists in the living kidney between the blood-vessels and the convoluted tubules. Dreser observed that with blood of a given concentration, urine would be excreted by the renal tubules which, though varying in concentration, was more concentrated than the blood, and that the function of the kidney was largely to reduce the osmotic pressure of the blood, and by carrying away the decomposition products in this manner to prevent their accumulation and fatal systemic poisoning. The practical study of these physical phenomena led Koranyi to develop a method whereby the functional activity of the kidney could be determined by a theoretically very simple procedure. As is well known, the boiling point as well as the freezing point of a liquid depends upon its molecular concentration; that is to say, the more concentrated a solution is, the higher its boiling point and the lower its freezing point, and liquids the boiling and freezing points of which are the same have the same molecular concentration. "The height of the boiling point of any liquid above that of distilled water, or, on the other hand, its lower freezing point, as compared with the same standard, is directly proportionate to the number of dissolved molecules which it contains" (Koranyi). It has been found more practical and more convenient to use the freezing point rather than the boiling point in determining these data. The freezing point of urine varies within rather wide limits,

according to the amount of water taken into the system. Under normal conditions it may be said to vary, according to the observations of Kümmell, between 0.9° and 2.0° C. below the freezing point of distilled water. Kümmell considered that if the freezing point is less than 0.9° C. below that of distilled water, an insufficient functional activity of the kidneys is certainly present. If the urines collected separately from each kidney differ widely in their freezing point, positive conclusions may sometimes be drawn as to whether one or the other is diseased, and sometimes the probable extent of such disease. Koranyi found that the *blood* of healthy human beings had a freezing point on the average of 0.56° C. lower than that of distilled water, and he determined experimentally that in health this relation hardly, if ever, varied more than 0.01 of a degree. Under pathological conditions, however, the freezing point of the blood may vary considerably. In anemic or cachectic conditions the freezing point of the blood will be more nearly that of water. In poisoning by carbonic acid the freezing point of the blood will be lower than normal. Further, it is observed that where the kidneys are not removing the decomposition products from the blood with proper rapidity, the freezing point of the blood is lower than 0.56° C., as compared with distilled water; and while in poisoning by carbonic acid the normal freezing point of the blood may be restored by passing oxygen through it, such is not the case when the freezing point of the blood is lowered as the result of renal insufficiency. The presence of acetone also changes the freezing point of the blood, making it lower, and treating the blood with oxygen in the presence of acetone makes its freezing point still lower, thus showing an opposite condition from that observed in carbonic-acid poisoning. The practical bearing of these data is chiefly in relation to extirpation of a kidney; that is, the possibility of determining by the freezing point of the blood the question of whether the one kidney remaining after nephrectomy will be in condition to do the work of two. Koranyi found that in the presence of renal insufficiency the character of the food exercised a marked influence upon the freezing point of the blood; but that if the individual were fed largely upon carbohydrates, this influence was reduced to a minimum. It is to be borne in mind in estimating the value of the freezing point of the blood in the given case that in individuals whose general nutrition is seriously impaired the freezing point of the blood may remain normal while the kidneys are really insufficient; that is to say, metabolism and excretion are reduced to a low degree of activity. Various disturbing elements have to be considered in estimating the freezing point of the blood in the given case. Thus it is found that anything which temporarily or permanently interferes with the circulation of the blood in the kidney may lower its freezing point. Thus, large abdominal tumors, notably tumors of the kidney, pregnancy; further, the presence of kidney stone, attacks of renal colic, and still other conditions, and these influences may be exerted upon the healthy or upon the diseased kidney, or both.

Kümmell formulated the rule that if the freezing point of the blood wa

more than minus 0.60° C. it indicated so high a degree of renal insufficiency as to contraindicate nephrectomy. At this time he was unaware of the disturbing influences which might be exercised by abdominal tumors, etc., and more recent experiments show that in certain cases a freezing point even as low as this is no contraindication to the removal of the kidney. The literature of this topic has already become fairly large, and contradictory opinions are entertained by equally competent observers. I do not feel that it is wise or necessary in a book of this character to describe at length the various differences of opinion of the several individuals who have paid especial attention to this topic, nor even to describe the technic of the theoretically simple, but practically somewhat complicated, methods in use for determining the freezing point of the urine or of the blood respectively. I may say, however, that in America at the present time the belief appears to be general that the cryoscopic examination of the total urine of twenty-four hours from both kidneys does not furnish data of much value. That the cryoscopic examination of the separated urines may give us confirmatory, sometimes quite reliable, information in regard to the functional activity of either kidney. Further, that the cryoscopic examination of the blood furnishes more valuable data than that of the urine, and when it can be used is valuable as confirmatory evidence of renal insufficiency, and may under special circumstances be a determining factor in the prognosis of cases of renal disease, or may even furnish strong confirmatory evidence for or against the operation of nephrectomy in the given case. In America certain practical difficulties exist in the use of the method, first among which is the fact that the average patient does not desire to have a vein of his arm opened and be bled to the extent of an ounce or more. Second, that, though simple in theory, the actual application of the method is fraught with a number of practical difficulties of considerable moment; the apparatus is a little complicated, it requires expert knowledge and practice to use it in a satisfactory manner, and personal errors of observation play a not unimportant rôle in the determination of the actual freezing point of the blood or urine respectively.

In an article ("Surgery, Gynecology, and Obstetrics," January, 1907, H. Kümmell ("Modern Surgery of the Kidney"), after an experience in the use of cryoscopy for the diagnosis of diseases of the kidney in more than one thousand cases, expresses the greatest confidence in the value of the method, and in the reliability of the results when accurately performed. Some of his conclusions are as follows:

(1) If the kidneys are intact, the molecular concentration of the blood is constant, and on the average corresponds to a freezing point of 0.56° C. This statement is based on the results of about seven hundred examinations. In weakened and anemic individuals, figures of 0.55° C., or even of 0.53° C. and 0.52° C., were sometimes observed.

(2) Unilateral disease causes no change in the freezing point of the blood.

(3) The normal freezing point, $\delta = 0.56°$ C., proves only that so much func-

tionating kidney tissue is present as is necessary to excrete completely the products of tissue metabolism. Theoretically, it might easily be assumed that the division of the work of the kidneys is such that each takes an approximately equal part in the excretion of the products of tissue metabolism, and that both together possess about as much healthy tissue as one normally functionating kidney. Under such circumstances the loss of one working half by operation might be expected to be followed by an insufficiency of the remaining half. In such a case the determination of the freezing point of the blood might give normal figures, which, however, would bear relation to the work of the two kidneys. That such errors may be avoided and the presence of a second kidney proved, ureteral catheterization should always be performed, and we have catheterized whenever it was possible. According to our numerous experiences, a normal freezing point generally indicates a second kidney, which, if not perfectly healthy, is nevertheless capable of functionating. Invariably, if the normal amount of urea was present in the urine, and a normal Δ was found on examination, then, also, the freezing point, δ of the blood was also found normal when one kidney was present, which, though not entirely healthy, was nevertheless equal to its duties because of the preponderance of healthy tissue. This, for example, we observed in a patient with only one hypertrophic kidney, who had an adrenal sarcoma. The kidney functionated perfectly, δ being equal to 0.57° C. The absence of the other kidney was shown by ureteral catheterization. Operation confirmed the diagnosed conditions; a nephrectomy was, of course, contraindicated. Also, in a case of injury of the kidney, in which there was a congenital absence of the other organ, the freezing point was normal, since an adequate amount of renal tissue still remained. We have had several similar experiences. I call special attention to these cases, as they prove that δ, speaks only for an adequate renal function, and that catheterization of the ureters must demonstrate the presence of the other organ, and should therefore never be neglected.

(4) A lowering of the freezing point of the blood indicates that the kidneys are not entirely equal to the required work. If δ falls to 0.6° C., according to our experience nephrectomy should not be undertaken, and nephrotomy only when absolutely necessary. Nephrectomy may follow only when the freezing point has improved and reached the normal. In case this does not occur, nephrectomy should not be considered. It is, of course, possible that after further experience the limits of what may be regarded as a normal freezing point will be broadened. The numerical value of 0.6° C. obtained by a correct and perfect cryoscopy may be entirely subjective. At any rate, according to our experience up to the present time, this figure represents the limit beyond which the removal of a kidney seems dangerous, and therefore is not recommended by us.

In five cases in which nephrectomy was performed, notwithstanding a lowering of the freezing point below 0.6° C., death occurred after a short time, accompanied by uremic phenomena. The other kidney was found extensively diseased at the autopsy. In about three hundred cases in which the freezing point was lowered below 0.6° C., the further course of the disease, the post-mortem examination or nephrotomy proved the correctness of our assumptions. In these cases we had to deal with bilateral disease of the kidneys (contracted kidney, parenchymatous nephritis), bilateral pyelonephritis, and bilateral tuberculosis, with tumors of both kidneys, bilateral renal calculi with and without complete anuria, bilateral cystic

kidneys, and with prostatic hypertrophy complicated by secondary disease of the kidneys.

Kümmell calls attention to the fact that cryoscopy of the blood is of very great value when catheterization of the ureters is impossible. He states as follows:

Cryoscopy of the blood has proved itself of inestimable value in that group of cases in which, notwithstanding great skill, ureteral catheterization was impossible. I refer particularly to those cases of kidney tuberculosis and suppuration which secondarily cause such an extreme contraction of the bladder and such an extensive ulceration of its mucous membrane that filling the bladder is impracticable, and any attempt at cystoscopy, let alone ureteral catheterization, is impossible, even though deep narcosis or spinal anesthesia be employed. The same is true of cases of renal disease in children in whom the narrow urethra does not permit the introduction of a cystoscope. In girls aged twelve and boys aged about fourteen years we found ureteroscopy possible. If the determination of the freezing point of the blood in these cases gave a normal δ, we considered this a proof that sufficient normal kidney tissue was present to excrete the products of metabolism. It was then only necessary to determine which was the diseased kidney. As is well known, in tuberculosis the results of palpation of the kidney are often negative, and no enlargement or subjective pain and tenderness are present from which the location of the disease, whether right or left, might be determined. In such cases we usually succeeded by palpation in making out a thickening of a ureter, and this gave a clew as to the probable side of the disease. The kidney on this side was thereupon exposed and, if extensively disorganized, removed. We have had no unsuccessful results when nephrectomy was done under such circumstances. We were forced to admit to ourselves that such an extensively diseased organ could take no important part in the work of excretion, and that the normal freezing point was necessarily due to a capable and sufficiently functionating organ, even though it might not be intact. If, on the other hand, we found a freezing point below 0.6°, or even more, we have declined to remove one kidney, since the other organ was evidently also diseased. The bilateral nephrotomy which we frequently undertook for the removal of the pus and the alleviation of the patient's sufferings has always confirmed our judgment. In the remaining cases the necropsy showed the correctness of our diagnosis of bilateral disease.

Kümmell further says that cryoscopy of the mixed urine is of no diagnostic value from the surgical point of view. The urine of each kidney must be tested separately.

CRYOSCOPY ALONE CAN NEVER DECIDE FOR OR AGAINST OPERATIVE INTERVENTION.

I have described our procedure in detail in order to meet the incorrect conception that we base the indication for or against operation on cryoscopy alone. This has never been the case. In every instance we have, whenever possible, catheterized the ureters, and also utilized the other well-known methods of examination. A careful analysis of the separated urines was made, and to the results so obtained were added the accurate and invaluable results of cryoscopy of the

blood performed in the manner described, and the results of this latter test utilized as a criterion, especially in those cases in which ureteral catheterization and the other methods were unsuccessful. This method has never failed us.

The Phloridzin Test.—The phloridzin test was utilized by Casper, and was based upon the observation of von Mehring, who observed that phloridzin injected subcutaneously was capable of producing a renal glycosuria, which was dependent for its intensity upon the functional activity of the kidneys. If the kidneys are healthy much sugar is excreted; if they are diseased less sugar will appear in the urine, and if the functional activity of a kidney is destroyed none will be excreted by that organ. Casper found that healthy kidneys excreted the same quantity of sugar in the same time. The examination is usually made from a half to an hour after the injection of the phloridzin, and in the following manner: The patient is given hypodermically a dose of phloridzin equivalent to 0.005 gm., combined with a small quantity of sodium carbonate in solution. Both ureters are then catheterized, the urine is collected from each kidney separately, and the relative proportion of sugar contained in the two specimens indicates the functional activity or want of such activity in either kidney. The quantity of sugar may be determined by one of the forms of polarizing apparatus in common use for the determination of sugar, or by the fermentation saccharometer. An absence of excretion of sugar from one kidney indicates, as already stated, that the function of that organ is destroyed; or if less sugar appears in one specimen than the other, it indicates a disturbance of function of greater or less degree in that particular kidney.

The functional activity of the kidneys may be tested in still another way: The patient is given a large quantity of water to drink—a quart or more; this causes the kidneys to excrete an increased quantity of diluted urine. The ureters are then catheterized, and the urine collected from either kidney from time to time and its freezing point determined. When the kidney or kidneys are diseased the appearance of a diluted urine is delayed. In case the function of one or both kidneys is seriously impaired, the increase in the quantity of urine may be slight or absent; further, the influence upon the molecular concentration of the urine will be notably slight. The results of this experiment usually coincide fairly well with the phloridzin test.

Another method of testing the functional activity of the kidney is to administer a hypodermatic injection of a five-per-cent solution of methylene blue. With normal kidneys the methylene blue will appear in the urine in an hour or more, reach its maximum coloration in a few hours, and disappear in from thirty-six to forty-eight hours. Some of the methylene blue is excreted as a colorless decomposition product known as chromogen. The color may be restored to the urine by adding a few drops of acetic acid and creson. In pathological conditions of the kidney it is alleged that the elimination of methylene blue is delayed or intermittent. As far as I am aware this test has not attracted

much attention in this country, and can scarcely be regarded as a highly useful diagnostic measure, since other methods of examination furnish more reliable results.

The value of the X-ray in the diagnosis of diseases of the kidney, notably in the diagnosis of renal calculus, is described in the chapter on the X-rays in Surgical Diagnosis. In all the diseases of the kidney when a surgical operation is contemplated for their relief, the examination of the urine plays a most important rôle in diagnosis, and an enormous amount of time, effort, ingenuity, and skill has been exhibited by numerous observers throughout the world to render these methods of examination accurate; and while it is often very easy to determine from the character of the urine discharged through the urethra that kidney disease is or is not present, the question of whether one or both kidneys are affected, and whether one remains healthy while the other is diseased; in other words, whether it is safe to remove one kidney, is a question by no means so easy to answer. The general question of disease of the kidney may readily be determined by the occurrence of albumen, the various forms of kidney casts, of kidney epithelium, blood, pus, and other materials in the urine. The question of which of the two kidneys furnishes the abnormal ingredients remains a very different and much more difficult matter to decide. In other words, before this question can be answered positively, it is usually necessary to collect the urine separately from each kidney. A large number of methods and of instruments have been devised for the accomplishment of this purpose. The methods in use at the present time consist of catheterization of the ureters and of methods which seek to separate the urine in two parts after it has entered the urinary bladder, and to collect these two urines representing either kidney separately. The first method, while usually more difficult, is by far the most reliable; the second method answers in a certain proportion of cases, and fails utterly in others. Catheterization of the ureters may be accomplished in one of two ways: First, by the use of the catheterizing cystoscope, an optical instrument introduced into the bladder, such that the operator sees the orifices of the ureters, and is thus able to introduce into them a ureteral catheter. Second, the direct method by the use of a straight tube passed through the urethra, illuminated by an electric light through which the surgeon introduces the ureteral catheter under the direct control of the eye without the interposition of lenses. The two methods will be discussed separately.

The Electrocystoscope.—*History.*—Although attempts were made in the early part of the last century to view the interior of the bladder through a tube introduced into that viscus with the aid of reflected artificial light, nothing of a very satisfactory character was accomplished until the invention of the electrocystoscope by Max Nitze, of Berlin. His instrument differed entirely in character, principle, and design from any then in existence. His first cystoscope was presented to the profession in 1879, but it was not until the year 1887 that the manufacture of small incandescent electric lights, which

could be introduced into the bladder as a source of illumination, rendered the modern instruments possible. The principle of the cystoscope, as designed by Nitze, consisted in the introduction of a source of light into the bladder, the viscus having been previously distended with water, and the observation of the distended and illuminated bladder wall by means of a telescope, so arranged as to increase the field of vision and render it distinct. The cystoscope as designed by him consisted of a metal catheter having the size of a No. 22 French sound or thereabouts, and eight inches and a half in length, having at its distal extremity a short beak similar to though somewhat longer than the beak of an ordinary catheter coudé of Mercier. In the tube of the beak there was a small incandescent electric lamp, enough metal being cut out from the upper surface of the beak to form a window, through which the rays of light from the lamp emerged. At the end of the shaft where it joined the beak there was placed a rectangular prism, the metal being cut away here also, exposing the superior surface of the prism. Rays of light striking upon this surface of the prism were totally reflected at a right angle down the tube to the ocular end of the instrument. The lamp was electrically connected with the ocular end of the instrument, one pole by an insulated wire, the current from the other being conveyed by the metal tube itself, ending at the ocular end in suitable terminals, connected with a source of electricity. The prism was placed upon the concave side of the instrument (*prismatic or indirect observation cystoscope*).

The Telescope of the Nitze Instrument.—With this instrument the interior of the bladder is viewed through the prism by means of a telescope, which consists of a straight metal tube containing a double plano-convex lens placed close to the prism, a single plano-convex lens about the middle of the tube; a true image is formed at the ocular end, which is magnified by an eyepiece consisting of a single large plano-convex lens.

The Leiter Instrument.—The Leiter instrument was constructed upon the same principles as that of Nitze, and varied from it only in detail.

Both these instruments were constructed in another pattern without any prism, the lamp being placed on the convex surface of the beak, the eye of the observer looking down the tube through a window at the end of the shaft. This latter type of instrument is known as the direct observation cystoscope. It is useful for inspecting the trigonum of the bladder, the ureters, and the fundus of the bladder in general. For purposes of catheterizing the ureter, as developed later, this form of instrument possesses the advantage that when the ureteric papillæ are found, it is easier to insert a catheter into their orifices than with the so-called indirect instrument. On the other hand, with the direct instrument the ureteric orifices are not so readily found and the visual field of the instrument is much smaller, since the end of the telescope must be close to the orifice of the ureter.

Since the invention of the Nitze instrument many improvements in the electrocystoscope have been made. Among the most important of these was

e invention of the so-called cool lamp by Dr. Henry Koch, of Rochester, . Y. This lamp gives a brilliant illumination, and never becomes hot enough burn the bladder wall. Another very important improvement was a change the telescope of the electrocystoscope designed by Mr. Wappler, of New ork, in 1899. This was made, I believe, for the late Dr. W. K. Otis. It as the first really satisfactory cystoscope made in America. The Wappler

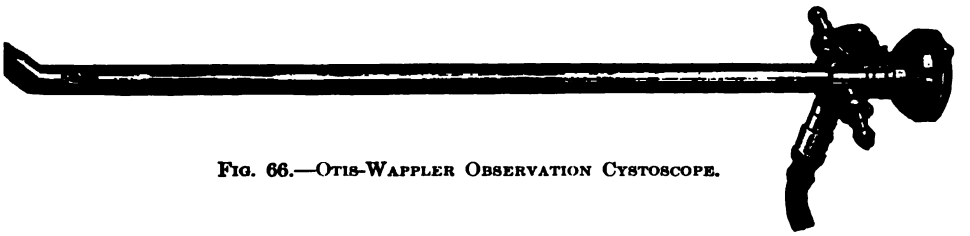

FIG. 66.—OTIS-WAPPLER OBSERVATION CYSTOSCOPE.

telescope possesses a lens system entirely different from that of previously constructed instruments. No prism is used, the terminal lens itself filling the water-tight window of the telescope, the light being diverted down the tube by a smaller mirror placed at an angle of forty-five degrees with the long axis of the telescope. This instrument, which has subsequently been developed to a great perfection by Dr. F. T. Brown, possesses peculiar advantages. The optical field is very much larger than is the case with any prism cystoscope of a similar size, and the field is not only larger, but also more brilliantly illuminated. The construction of the sheath of the instrument is such that the insulation occupies a minimum of space. Another great advantage is that the entire optical apparatus is included in the telescope, and in the simple observation cystoscope; the instrument may be introduced into the bladder with the telescope *in situ*, but with the lens turned away from the window; by simply rotating the telescope after it is in the bladder the lens is brought into the window. In this way all smearing of the lens with pus, blood, lubricating material, etc., is avoided. Moreover, if the fluid in the bladder becomes cloudy, the telescope may be withdrawn, and the sheath of the instrument may then be used as an irrigating catheter in every way more efficient than the minute channels provided in some other cystoscopes for this purpose. The instrument, having no sharp angles, is easily introduced and produces less traumatism than any other form. Particularly as a result of the labors of Dr. F. T. Brown and of Mr. Wappler, the optical apparatus and the illumination, together with the additional devices for catheterization of the ureters, have been greatly improved and simplified. All parts of the bladder may be brought into view through the same sheath, since both a terminal and lateral window are provided. By cutting away the metal of the beak, thus exposing both front and back surfaces of the electric light, all parts of the bladder are equally, or almost equally, illuminated. When using the indirect method of catheterizing the ureter, it is necessary to have a mechanical device

for moving the tip of the urethral catheter, so that it may engage in the urethral orifice. This is accomplished by the aid of a small movable finger in which the tip of the catheter rests, which can be operated under the control of the eye from the optical end of the instrument (Albarran). Within

FIG. 67.—BEAK OF A CATHETERIZING CYSTOSCOPE OF THE INDIRECT TYPE. Showing Albarran's device for depressing the shaft of the catheter in order to make it engage in the ureteric orifice. (Watson and Cunningham.)

recent years the development of the operation of prostatectomy has made it very desirable to produce a cystoscope with which the surgeon might readily inspect that portion of the bladder surrounding the internal urethral orifice. The instrument devised by F. T. Brown, and another by Bransford Lewis, answers this purpose fairly well. In 1903 a very ingenious instrument was presented to the profession by Dr. Felix Schlagintweit, of Munich. This instrument has a second reflecting prism, connecting by a hinged joint with the first, which in this case is a part of the telescope and not fixed in the sheath. The second prism is movable, so that after the instrument is introduced into the bladder, advancement of the telescope causes the movable prism to revolve, so that two right-angled prisms come to be superimposed; the upper one looking directly toward the internal urethral orifice and the other receiving the reflected light from the one above, transmits the image of the neck of the bladder directly to the eye of the observer. This

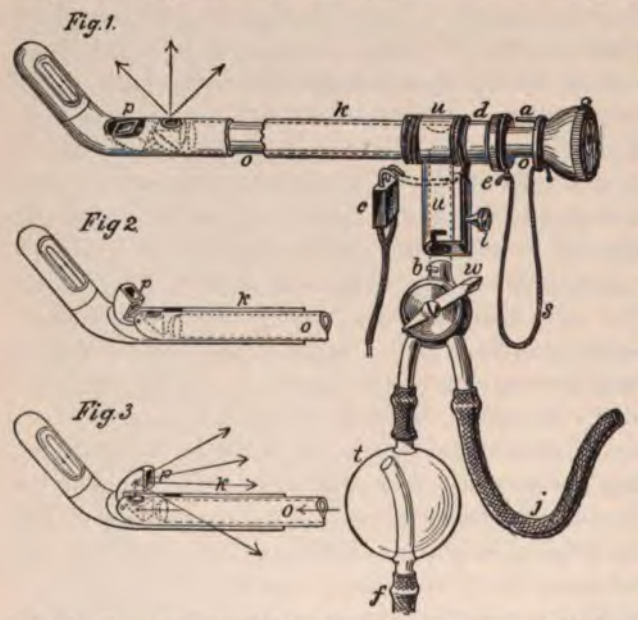

FIG. 68.—SCHLAGINTWEIT'S RETROGRADE CYSTOSCOPE. *Fig.* 1. Instrument in position for right-angled view. *Fig.* 2. The second prism is partly extruded from the shaft of the instrument. *Fig.* 3. The second prism is fully extruded and in position for retrograde inspection of the anterior wall of the bladder.

apparatus, however ingenious, does not furnish as perfect an illumination of the portion of the bladder close to the internal urethral orifice as could be desired. Indeed, I am informed, in a personal communication from Dr. F. T. Brown, that no instrument has as yet been devised which may be regarded as a perfectly satisfactory retrograde cystoscope. The object has been accomplished in Brown's instrument by increasing the section of the spherical lens used in his instruments and giving it a slight tilt. Still, the illumination of the vesical neck is not entirely satisfactory. The most recent models (March, 1909) of the Brown cystoscope accomplish what is desired, not only for observation and study of the interior of the bladder, but also for urethral catheterization in a very perfect manner. The instrument is known as the Brown composite cystoscope. For all ordinary purposes, both for observation and catheterization of the ureters, a single sheath is sufficient, into which several different telescopes may be passed for observation merely or for catheterization of the ureters either by the direct or indirect methods. The telescope of the instrument, with its attachments for catheterization of the ureters by the indirect method, is, so Dr. Brown tells me, quite satisfactory for use as an observation cystoscope, although a larger telescope, of course, gives better illumination and a broader field. There is in this instrument a small movable finger, originally the device of Albarran, for bending the catheters so that they may be made to enter the ureteric orifice.

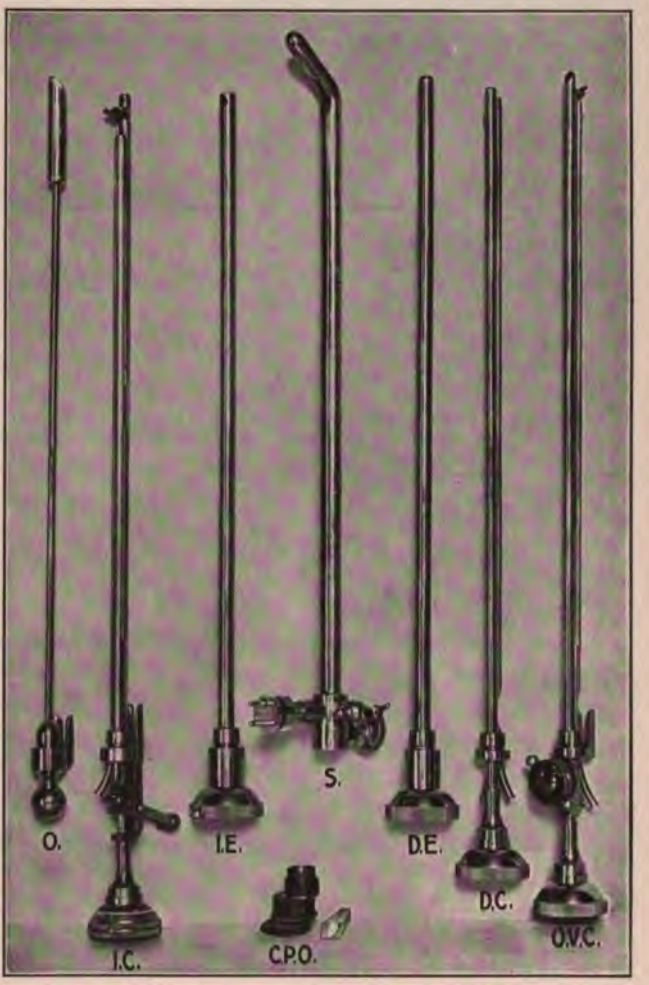

FIG. 69.—BROWN'S COMPOSITE CYSTOSCOPE. *O.* Obturator. *I.C.* Indirect catheterization. *I.E.* Indirect examination telescope. *S.* Sheath. *C.P.O.* Attachment for correcting transposed image. *D.E.* Direct observation telescope. *D.C.* Telescope for direct catheterization. *O.V.C.* Telescope for indirect catheterization.

While the indirect method of catheterization gives a larger field, and quently permits one to find the ureteric orifices more readily, it suffers several practical disadvantages. It is more difficult to introduce the cath and after they are introduced, the instrument, in order to withdraw it

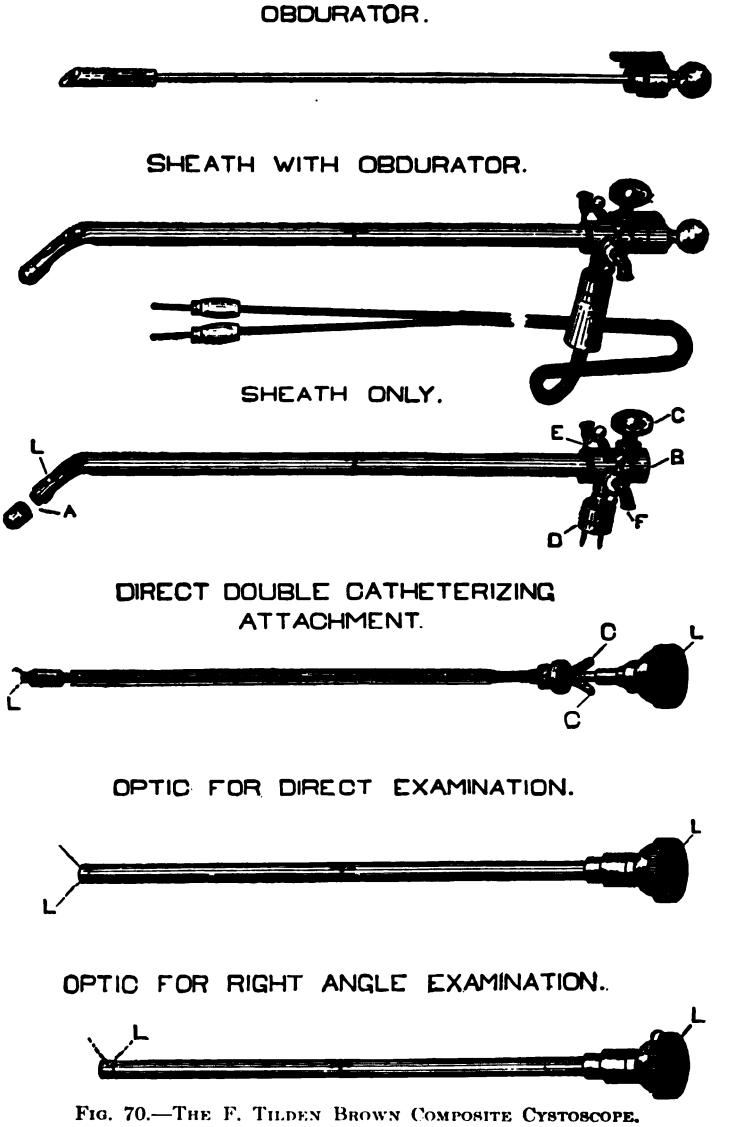

FIG. 70.—THE F. TILDEN BROWN COMPOSITE CYSTOSCOPE.

the urethra, must be rotated, so that its beak, pointed toward the floor bladder during the introduction of the catheters, points toward its apex catheters are thereby crossed, and some part of the apparatus is very bind. Not only is this a mechanical disadvantage, but also in the a to get the catheters loose, so that the instrument can be withdrawn, the

be moved back and forth. Almost inevitably the mucous membrane of the ureters is wounded to such an extent that the urine flowing from the catheters is pretty sure to be blood-stained, either microscopically or macroscopically. In either case the object of the catheterization may be defeated, since it often happens that the important question is, Does blood flow from either ureter or both, and, if but one, which one? During the entire performance of urethral catheterization it is for this and similar reasons highly important that the instruments should be kept as quiet as possible in the bladder, thus avoiding unnecessary trauma, with its attendant hemorrhage and irritation. These several advantages can in the average case be accomplished far better by the direct method of catheterization. In order to overcome the difficulty encountered in attempting to catheterize the ureters by the direct method when the trigonum falls away from the internal urethral orifice, the latest model of the Brown composite cystoscope has a small movable finger, so placed that in catheterizing by the direct method the catheters can be displaced backward and more readily engaged in the ureteric orifice. The several parts of the instrument are shown in the illustrations. In addition, a larger section of a sphere is used for the lens, so placed that the operator's vision collects rays from a point farther in front of the orifice of the telescope than is the case with the ordinary right-angled arrangement of the lens. This modification permits the observer to find the ureteric orifice more readily by what Dr. Brown calls "oblique vision." When this same lens is turned posteriorly instead of anteriorly, it becomes the lens of the retrograde cystoscope. The most recent and, it is believed, the most efficient modification of the Brown catheterizing cystoscope by the indirect method was devised by Dr. Leo Buerger, of New York (*Annals of Surgery*, February, 1909, page 225). As in Brown's instrument, the cystoscope consists of three parts—the sheath, the obturator, and the catheterizing telescope. The instrument is of a caliber of 24 French. "The catheterizing telescope combines in one piece the optical apparatus (Otis-Wappler), the mechanism for deflection (Albarran), and the catheter grooves or beds. . . ." In this instrument the light, the lens, and the finger for deflec-

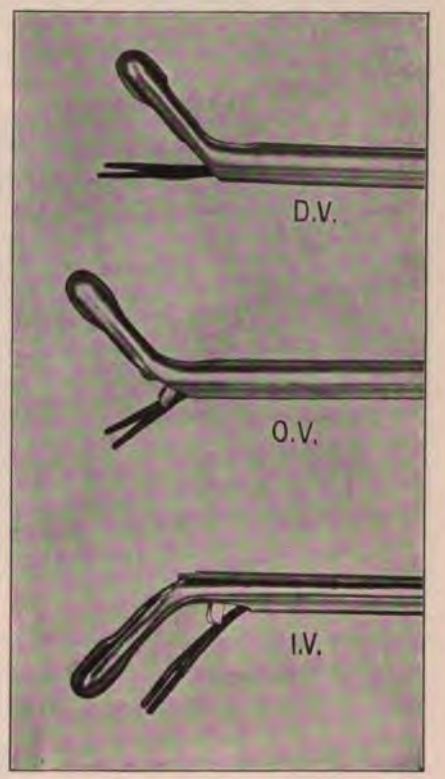

FIG. 71.—BROWN'S COMPOSITE CYSTOSCOPE FOR URETERAL CATHETERIZATION. *D.V.* Direct vision. *O. V.* Oblique vision. *I.V.* Indirect vision.

tion of the catheter are brought into the closest possible apposition—an advantage optically and mechanically. Dr. Buerger describes the technic of finding the ureter and of the introduction of the catheter in accurate terms

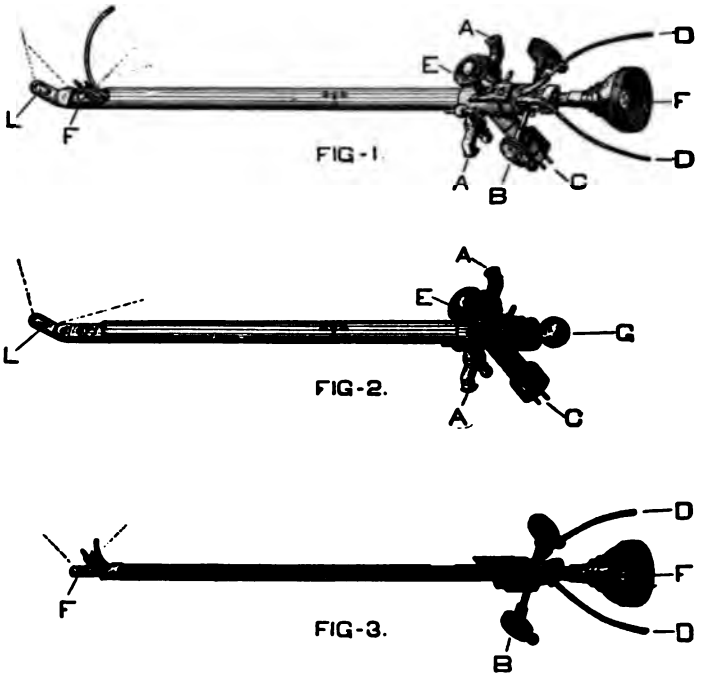

FIG. 72.—THE BROWN-BUERGER COMBINED EXAMINING, IRRIGATING, AND CATHETERIZING CYSTOSCOPE.

(See original article.) After the catheter is precisely in the proper position in reference to the ureter, the shaft of the instrument itself is pushed onward so that as the point engages in the ureteric orifice the entire instrument, and not the catheter alone, is advanced. The author states, also, that by suitable manipulations the cystoscope may be removed from the bladder, leaving the catheters *in situ* without any special violence or difficulty.

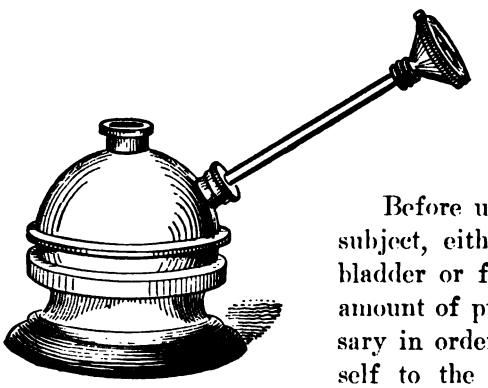

FIG. 73. — LEITER'S BLADDER PHANTOM FOR PRACTICING CYSTOSCOPY.

Before utilizing the cystoscope upon the living subject, either for the purpose of inspecting the bladder or for catheterizing the ureters, a certain amount of preliminary practice is absolutely necessary in order that the surgeon may accustom himself to the optical peculiarities of the different forms of the instrument. As stated when quoting from Brown, formalized human bladders are rather

than artificial phantoms. Still, the latter will answer if the former be obtained. Artificial bladders are constructed by many firms; among iplest is Leiter's phantom; a much more elaborate one is that of Janet nk. This permits not only the inspection of the bladder, but also heterization of the ureters. Ordinarily, the phantoms are made in the f a more or less spherical box containing water, upon the interior of are painted the blood-vessels, the mouths of the ureters and other struc- he attempt being made to imitate as far as possible the color and general ance of the actual bladder. Foreign bodies of one sort or another may introduced into the m. One of the first ties encountered in ny of the prism cys- s is the fact that the as in the laryngo- is a reflected one, therefore reversed ust undergo a men- rection in order to ine the true posi- objects in the field. y in this direction ly be acquired by rable practice. F. ine has constructed genious apparatus he calls the box m. Its intention is mit the student to he optical peculiar- the cystoscopic im-

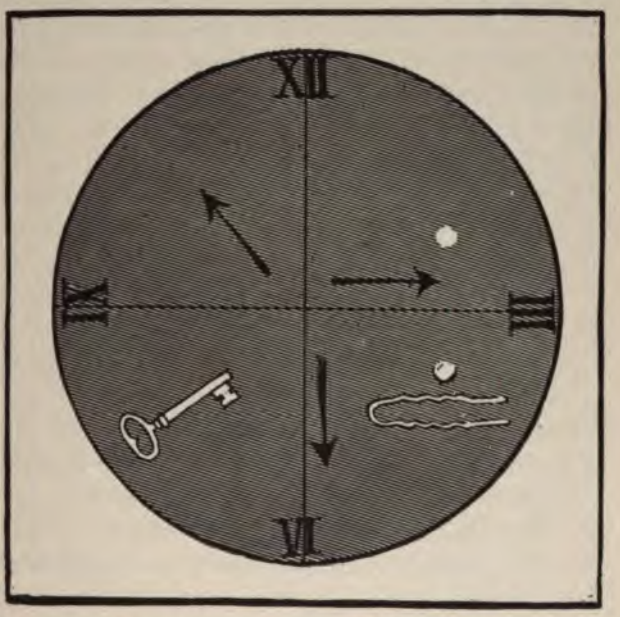

FIG. 74. — SCHEMATIC BOTTOM OF VALENTINE CYSTOSCOPIC BOX PHANTOM. (F. C. Valentine, *New York Medical Journal*, 1903.)

the different forms of cystoscope. The reader is referred to Dr. Val- s publication for the details.

addition to the details of technic quoted from Brown, under the use catheterizing cystoscope, the following practical cautions are adapted V. K. Otis: When it is proposed to examine the bladder with a cysto- t is best, if possible, to have the patient under observation for a few fore the cystoscopic examination is made, and to go through a prelim- xamination. It may be impossible to pass the cystoscope at all, either unt of a narrow meatus, stricture of the urethra, or enlargement of state. The capacity of the bladder may be less than two ounces. Blood may be present in such quantity as to render the examination futile, or eral condition of the patient may be such as to render the introduction cystoscope inexpedient. While in most cases cystoscopic examination

may be made under cocain anesthesia without causing the patient undue pain or suffering, yet in children, in very nervous individuals, and in cases where an extraordinary sensitiveness of the urethra, prostate, or bladder is present—and these are usually males—a general anesthetic may be advisable. When using the cystoscope for the purpose of catheterizing the ureters, on the other hand, a general anesthetic is to be avoided if possible, on account of the changes produced in the urine by the administration of ether. Before beginning the examination the cystoscope should be tested to see that the lamp, cords, electric connections, and battery are in good working order. As the lamps differ one from another, it is necessary that each should be tested separately by placing the tip of the instrument in a vessel of water and slowly increasing the current with the rheostat until the lamp emits a brilliant white light, taking care, however, not to burn out the filament. If small bubbles arise from the junction of the shaft with the beak obscuring the lens, it is due to the decomposition of the water by the electric current, and may be prevented by rubbing the joint with a little wax. The position of the patient during the cystoscopic examination will be found described in Brown's technic of the catheterization of the ureters.

In the use of cocain in the urinary bladder a certain amount of caution is wise. Some dangerous cases of poisoning and, indeed, fatal results have been reported by different observers. The plan of Brown, subsequently described, is to use as small a quantity as possible. Nitze uses about 50 c.c. of a two-per-cent solution or 15 grains of cocain, permitting the solution to run out of the bladder, however, before distending it for examination. Fenwick injects a drachm of a twenty-per-cent solution into the bladder, 3 or 4 ounces of a boric-acid solution having been previously introduced. This is retained during the examination. He then injects more of the twenty-per-cent solution into the deep urethra, and says: "No apprehension need be felt about the cocain; I have used injections of cocain in large out-patient practice, and have never seen any case presenting symptoms of so-called cocain poisoning." Willy Meyer, however, reports a case in which decided and alarming poisoning occurred after the introduction of 50 c.c. of a two-per-cent solution of cocain diluted with three or four ounces of sterilized salt solution. Albarran reports a death after the injection of two ounces of one-per-cent solution in a case of irritable bladder with stone, in spite of the fact that the solution was withdrawn and the bladder washed a few minutes after its introduction. It is to be borne in mind that trauma, ulceration, or any condition in which the bladder is denuded of its epithelium renders the absorption of cocain very much more rapid.

Dr. Otis says: "I am in the habit of using 10 or 20 minims of a four-per-cent solution of cocain, placed in the prostatic urethra by means of an Ultzmann syringe, disregarding the anterior urethra and bladder, and usually find the amount of local anesthesia obtained sufficient to conduct a satisfactory examination." When the bladder is extremely irritable and the condition a

painful one, morphin may be used subcutaneously. The use of antipyrin, as recommended by Guyon, is sometimes useful. The following solution may be injected into the rectum three quarters of an hour before the examination: Antipyrin, 14 grains; laudanum, 10 minims; water, 3 ounces. This usually produces a degree of anesthesia such that cocain may be dispensed with. A cystoscopic examination can only be made satisfactorily in a clean bladder. A very small amount of blood or pus in the liquid will cause a dim and imperfect picture. In ordinary cases the bladder should be emptied before the introduction of the cystoscope by means of a silk catheter coudé, and then repeatedly and gently washed out with warm boric-acid solution injected through a 5-ounce hand syringe (Ultzmann's hand syringe or Janet's syringe), and the washing should be continued until the solution returns absolutely clear, when 5 ounces should be introduced and permitted to remain for the examination, this being the quantity which has been found experimentally to obliterate the folds of mucous membrane in the normal bladder. When bleeding from the bladder or posterior urethra is so active that the fluid rapidly becomes discolored, hemostasis may sometimes be obtained by injecting into the bladder a solution of adrenalin (1–1,000), leaving it in the bladder for ten or fifteen minutes, and then washing it out. When an active cystitis is present, it is sometimes necessary to put the patient in bed and treat the bladder by irrigations until the condition is so far improved as to permit a satisfactory examination. Fenwick prefers, when the urine is clear, to examine the bladder through this medium, and permits the patient to retain five or six ounces of urine in his bladder at the time of the examination. Most surgeons prefer to use either boric-acid solution or 0.9-per-cent salt solution. The use of air for purposes of distending the bladder is not in general very satisfactory (see quotation from Brown on ureter catheterization). The various details in the technic of the introduction of the instrument and the other procedures sometimes necessary during the examination of the bladder are fully described under catheterization of the ureters.

The appearance of the normal bladder and of the mouths of the ureters as seen through the cystoscope, as well as the various changes observed in these structures as the result of disease, is only to be learned by practical experience. The following brief description of some of the appearances in relation to disease of the kidney and ureter are adapted from Brown: Through the cystoscope the mouth of the ureter may appear as a faintly pinkish slit in a low papilla of yellowish-white mucous membrane, in other cases as a conical dimple upon a more pronounced papilla, or there may be but one visible lip to the ureter, just in front of which lies the normal orifice. It is to be borne in mind that disease of the kidney may coexist with a ureteral orifice which appears to be entirely normal. In cases of disease, the mouth of the ureter may present as a considerable tumor or as a depression. When a prominence of some size is present its color may vary from red to glistening white, the latter being caused by translucent, edematous tissue, illuminated by the electric

light. In some instances it may be possible to see in the orifice of a bulging ureter a brownish body recognized at once as the end of a calculus, and if no stone be seen, the mere fact that the mouth of the ureter is swollen and edematous will lead to the suspicion that a stone is present higher up. If the orifice of the ureter is distinctly inflamed, it will suggest disease of the corresponding kidney. If in the inflamed area surrounding the ureteral mouth an ulcer is present, it is probably tuberculous. If in place of a prominence a distinct ulcerated depression is seen, surrounded by a reddened border with an uneven base, the diagnosis of tuberculosis is exceedingly probable. When the entire trigonum is uneven, reddened, and opaque, so that the mouths of the ureters cannot be discovered, it is probable that the kidney has been discharging infectious urine or minute calculi for some time. Translucent ovoid bodies in the mucous membrane of the bladder suggest an extra vesical new growth. When the mouths of the ureters are atypical in location or number, some congenital abnormality of the kidney probably exists. In regard to the character of the urine issuing from the mouth of the ureter, the gushes of urine which occur every ten or fifteen seconds or so may be entirely clear; they may be distinctly bloody or purulent, or at least cloudy with some foreign material, and are, when abnormal in appearance, of great value in diagnosis as indicating disease of the higher portions of the genito-urinary apparatus, the kidney, or the ureter. They rarely, however, permit us to make more than a probable diagnosis of the exact pathological lesion without the use of other methods of examination—i. e., the physical examination of the kidney in the loin, ureteral catheterization, and analysis of the separated urines.

There is a tendency among certain surgeons to place a very high value upon the mere cystoscopic appearances of the ureteric mouths and trigonum, the appearance of the urine as it gushes into the bladder, and to feel that the diagnosis of kidney disease may be made exactly from these data at least to a sufficient extent to furnish operative indications. While this is to a certain extent true, the surgeon who in addition catheterizes the ureters will acquire additional and valuable data, and may save himself from grievous errors. Moreover, as already suggested, the ureteric mouths may appear normal in the presence of tuberculosis of the kidney. Thus, Brown relates three instances where no abnormality was noticeable in the condition of the mouth of the ureter while a catheter introduced withdrew urine containing tubercle bacilli and the operation confirmed the diagnosis of tuberculous kidney. The results of ureter catheterization in bleeding from the kidney are often very valuable, although at times disappointing. It is of course possible by this means to determine the source of the bleeding, but its pathological causation sometimes remains obscure. The three most common conditions other than trauma which lead to hemorrhage of the kidney are stone, tuberculosis, and malignant new growths of the kidney. In the absence of tubercle bacilli we cannot, as a rule, exclude tuberculosis without frequently repeated tests. With a negative X-ray finding and the absence of inflammatory products in the urine we are some-

imes able to exclude renal calculus. The next most probable diagnosis is alignant tumor, and this type of renal hematuria will, of course, in time be ccompanied by the formation of a palpable tumor. Other conditions to be escribed later at length are congenital cystic degeneration of the kidney, ilharzia hematobium, and some other conditions to be mentioned.

For a more complete description of the cystoscope and of its use the reader s referred to the publications of Nitze, Berkeley Hill, Hurry Fenwick, Thompson, Boisseau du Rocher, Casper, Albarran; and, in America, Taylor, Ayres, Brown, Otis, Bransford Lewis, Valentine, Bierhof, and others.

Some Hints in Regard to the Technic of Catheterization of the Ureters, Adapted from F. T. Brown's Article on this Topic

In order that the examination shall be conducted successfully, it is necessary that the surgeon should have everything he is likely to need within easy reach of his right hand, so that the left hand may be left constantly free to retain the cystoscope quietly in position after it has been introduced into the bladder. The steadiness with which the cystoscope is held and the gentleness with which it is moved have much to do not only with the comfort of the patient, but also with the success of the entire procedure.

The operation of cystoscopy with catheterization of the ureters is at best a trying one for the patient, and hence it is important that he should be so placed and supported upon the table that all his muscles may be at rest. To this end it is desirable to use a table fitted with leg rests, such that both the legs and thighs may be well supported. The leg rests may be made in the form of double-inclined conical gutters, the apices of which conform to the flexures of the knees. The patient should be so placed upon the table that the buttocks are as close to its edge as possible. It is desirable to use a table of such a character that the parts supporting the patient's back can be elevated to any desired degree, and such that the entire back, including the lumbar region, receives support. After the patient has emptied his bladder voluntarily, the specimen passed is preserved for comparative examination with those withdrawn through the ureteral catheters. The patient having been comfortably placed upon the table, a little cocain solution (two- to four-per-cent) is introduced into the urethra. After a few moments a soft-rubber catheter is introduced into the bladder, and any residual urine is withdrawn. The bladder is then irrigated, if the urine has been at all purulent, with a two-per-cent warm boric-acid solution, or with equal parts of 0.9-per-cent salt solution and four-per-cent of boric acid. This fluid is also used to distend the bladder during the cysto-

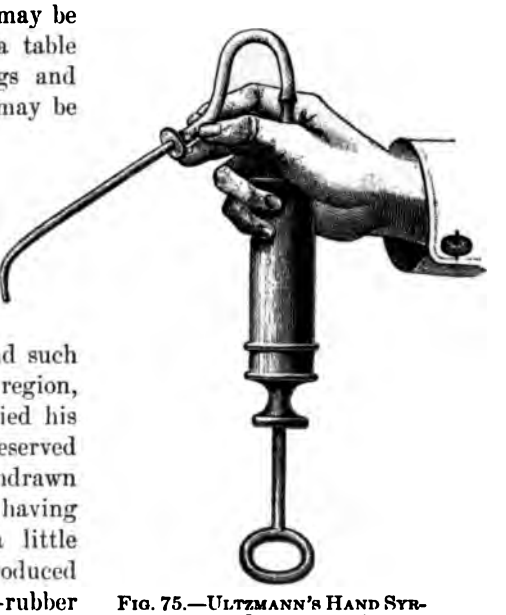

Fig. 75.—Ultzmann's Hand Syringe and Irrigating Catheter.

scopic examination. For irrigating the bladder one may use an Ultzmann or a Janet syringe, or the bladder may be irrigated by means of a glass irrigating jar, the fluid being permitted to flow into the bladder by gravity. After the washing fluid has returned quite clear the posterior urethra may be rendered anesthetic by the introduction through the catheter, or by means of the Ultzmann drop syringe, of a solution of cocain (four-per-cent). From 4 to 10 c.c. of this solution, introduced into the posterior urethra, are usually sufficient to produce a satisfactory degree of anesthesia. When the posterior urethra is anesthetic a soft-rubber cathe-

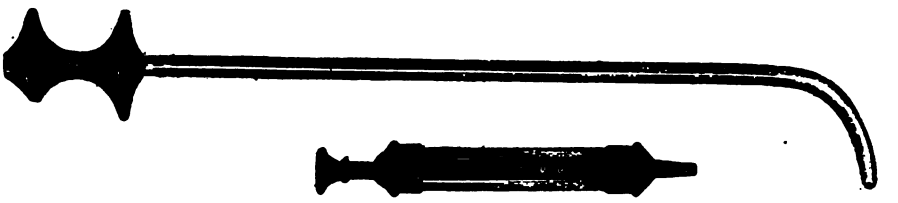

FIG. 76.—ULTZMANN'S SYRINGE FOR INSTILLATION IN THE DEEP URETHRA. The shaft of the instrument must be made of silver; its caliber is of such a size that one of the divisions on the shaft of the piston is equal to the fluid contents of the entire shaft.

ter may be passed into the bladder, and through it a quantity of the solution may be introduced which will vary somewhat in different cases. Four ounces is a moderate quantity, but more may be used in case it does not produce a sensation of distention and discomfort. In cases where the urine is quite clear or nearly so, it will not always be necessary to irrigate the bladder before introducing the cystoscope. Under such circumstances the cystoscope, with its obturator in position, is carefully introduced into the bladder. The obturator is then withdrawn, and if it is desired to substitute fresh clean solution for that which is in the bladder a rubber catheter may be inserted through the sheath of the instrument. Such a catheter may be surrounded by a movable rubber belt, which acts as a cork to prevent the solution from running out between the catheter and the sheath of the instrument. Before the cystoscopic examination is commenced boric-acid solution may be added by attaching the catheter to a syringe or an irrigator. When the bladder is believed to contain a sufficient quantity of fluid any one of the several telescopes of the instrument may be introduced through the sheath in place of the catheter, the lamp may be illuminated and the examination of the bladder commenced. Whether or not it is desired to introduce catheters into the ureters, it is not a bad plan to introduce first the direct observation telescope, which gives a larger field and more brilliant illumination, or the right-angled observation telescope, since through these instruments the interior of the bladder may be studied and the situation of the mouths of the ureters may be determined. In order to substitute one telescope for another the following procedure is recommended by Brown: "When any of these telescopes is withdrawn a trifle so that the vesical end has come wholly within the sheath, the latter can itself be slightly withdrawn until the heel opening comes just to the internal meatus; by now raising the ocular end to more or less of an angle with the plane of the patient's body, the distending medium in the bladder will be prevented from escaping, while the telescope is wholly removed, and the next telescope, when well within the sheath, calls for a lowering of the ocular end, so as to prevent the impact of its vesical

end upon the neck of the bladder. After a little practice one can make such changes with perfect success, and thus save the time otherwise required for a renewed introduction of distending medium with each succeeding telescope." The interior of the bladder having been studied, one or other of the telescopes containing ureteral catheters is introduced. As already stated, the direct telescope renders it easier to pass the ureteral catheter when the papilla has once been located, but, on the other hand, the indirect telescope permits one to see the ureteric orifice more easily. Whichever one is used, the task of the surgeon is first to find the papilla, and then to introduce into the ureteric orifice of one side the ureteral catheter. Here it must be said that considerable practice is necessary to do this readily. All the manipulations should be made with extreme gentleness from beginning to end. If the slightest roughness is used in the manipulations, the surgeon will be pretty sure to find himself looking through a blood-stained medium, and will identify the orifices of the ureters with difficulty, if at all. In the cystoscopes of Brown, arrangements are made for continuous irrigation of the bladder with fresh solution, if such is required; and thus the medium may be kept reasonably clear throughout the examination. When the surgeon has succeeded in engaging one of the catheters in the mouth of a ureter, the instrument is gently pushed inward a distance of about two and a half inches. The cystoscope is maintained by the left hand at precisely the same inclination to the horizontal, and the ocular end is slowly moved in a lateral direction through an arc of thirty or forty degrees, until the orifice of the other ureter comes into view. It is important to make this movement very slowly and gently, since otherwise the catheter already passed may cause undue tension and traumatism on the mouth of the ureter. The mouth of the second ureter having been found, the second catheter is inserted to a distance of about two inches. The caps which have previously covered the outer ends of the catheters are now removed, and the urines are collected in bottles marked "Right" and "Left." If it is desired to make cultures from the urine, five or six drops may be allowed to fall from either catheter upon suitable culture media in labeled "culture tubes." During the time when the urines are being collected, some of the water contained in the bladder may be allowed to escape through the outlet in the cystoscope provided for the purpose. The patient will thus be rendered more comfortable. While many surgeons prefer to remove the cystoscope and to leave the catheters in position, Dr. Brown informs me that he is in the habit of leaving the cystoscope in the bladder while the urine is being collected, holding it constantly in position with his left hand. If it is desired, however, to remove the cystoscope, it may be done when using the direct method of catheterization without much trouble. In order, however, to remove the cystoscope with the catheters in position, when using the indirect instrument, not a little skill is required in order to prevent an undue amount of traumatism to the ureters, and the consequent contamination of the specimens with microscopic or gross quantities of blood, thus in many instances invalidating the purpose of the whole procedure. The source of electric illumination for cystoscopes may be one or other of the forms of "electric controllers" now on the market attached to the street current, or, on the other hand, dry-celled batteries or storage batteries may be used. The voltage of the cold electric lamps now in general use is very small, and a dry-celled battery of ten cells furnished with a small rheostat furnishes a current satisfactory in every way.

From six to twelve cubic centimeters of urine should be collected from each kidney, for purposes of analysis and microscopic examination. For taking the specific gravity of such small quantities of urine the Westphal balance is the most convenient instrument.

For the purpose of practicing the operation of ureteral catheterization Dr. Brown recommends the use of bladders removed from the bodies of human beings

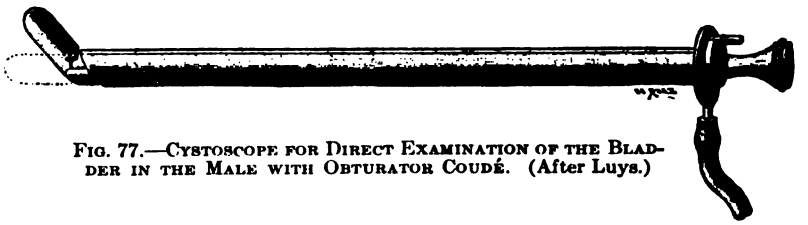

FIG. 77.—CYSTOSCOPE FOR DIRECT EXAMINATION OF THE BLADDER IN THE MALE WITH OBTURATOR COUDÉ. (After Luys.)

of both sexes and suspended in a two-per-cent solution of formalin, 5 or 6 ounces of the same being used to distend the organ. In removing a bladder, one inch of urethra and three or four inches of each ureter are suitable portions to leave attached. Very small bougies should be passed through the ureter stumps, so that the orifices may remain a little patent; otherwise they will be difficult to recognize and impossible to enter with a catheter. In order to have the bladder retain a steady position while manipulating the cystoscope, it is well to pin the viscus with small staples to a wooden block, which has had a concavity made in it for the reception of the base of the bladder. A series of such bladders will illustrate very well the many changed conditions one has to expect in performing cystoscopy and ureteral catheterization on the living subject.

Catheterization of the Ureters through a Straight Tube by Direct Vision.—Gustav Simon, and later Pawlik, catheterized the ureters of the female suc-

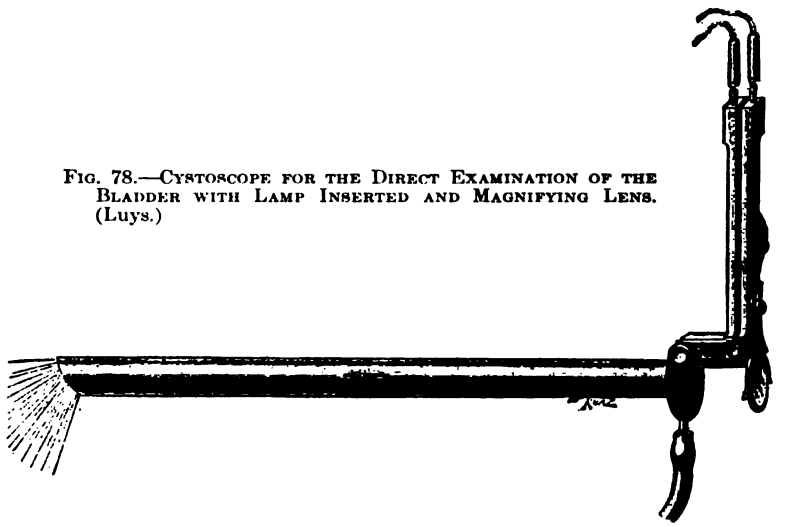

FIG. 78.—CYSTOSCOPE FOR THE DIRECT EXAMINATION OF THE BLADDER WITH LAMP INSERTED AND MAGNIFYING LENS. (Luys.)

cessfully in a good many cases by the direct method or by the sense of touch. Simon showed that the female urethra might be dilated quite widely without

serious injury, but it remained for Howard Kelly, of Baltimore, to develop the method to its present state of usefulness. While generally only applicable to women, catheterization of the ureters in the male through a straight tube, by direct vision, has been accomplished successfully by Kelly and by Robert T. Morris, Bransford Lewis, and others. It is certain, however, that this method for the catheterization of the ureters in the male can never be employed except by a few highly skilled specialists. In the female the catheterization of the ureters by the direct method is so easy that any surgeon of average skill can accomplish it in simple cases at the first trial. The use of Kelly's method is very general at the present time, and while in highly skilled hands the ureters can be catheterized in the female through the electric cystoscope with comparative ease, this method also will always remain chiefly in the hands of specialists. The following are the principles of Kelly's method: The atmospheric distention of the bladder by the posture of the patient—i. e., the knee-chest posture or the lithotomy position with elevation of the hips, the introduction of a simple cylindrical speculum into the bladder, illumination of the interior of the bladder by means of a head mirror or of an electric headlight, and the subsequent inspection of the interior of the bladder, finding of the ureteral orifices, and the introduction into them of catheters.

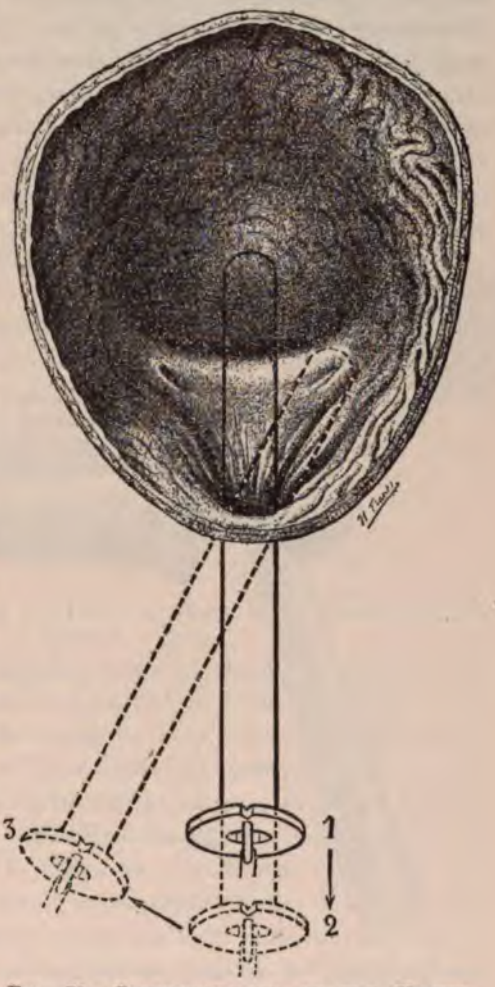

FIG. 79.—CATHETERIZATION OF THE URETER THROUGH A STRAIGHT TUBE. (After Luys.)

The instruments which are used for catheterization of the ureters are an electric headlight or other strong source of artificial light, a 32-candle-power lamp—set in a white enamel reflector, for example—and a head mirror, a series of vesical specula with obturators, a urethral calibrator and dilator, an evacuator for removing the urine from the bladder, although this may in many instances be dispensed with, a pair of long mouse-toothed forceps, a ureteral searcher, a metal ureteral catheter, and flexible varnished silk long and short ureteral catheters, occasionally solid ureteral bougies, and for the

purpose of detecting stone in the ureter a ureteral bougie coated near its end with wax. Personally I have always found it much easier to catheterize the ureters in the female by using as a source of illumination a good electric headlight, run by a suitable storage battery or the modified direct street current, with the interposition of Wappler's electric controller, or the controller of the Electrosurgical Instrument Company of Rochester, N. Y. Sunlight and a head mirror may also be used, although not always available. Gas or oil lamps are undesirable. When using a head mirror, it should be such a one as is ordinarily used for the examination of the throat and larynx, with a focal distance of twelve inches.

The specula which are introduced through the urethra are metal cylinders made of German silver, nickel-plated, about three inches and a half in length, set upon a strong handle with a conical expansion at the outer end of the tube. Each speculum has an obturator, with a large, strong handle and a bluntly conical vesical end fitting snugly into the vesical end of the speculum, which should be so constructed that no sudden, sharp shoulder exists which might injure the urethral mucous membrane during its introduction.

FIG. 80.—URETHRAL CALIBRATOR AND DILATING INSTRUMENT FOR THE FEMALE URETHRA. (Kelly.)

The specula are made in sizes ranging from 5 to 20 mm. in diameter. The sizes ordinarily used are from 7 to 12, it being rarely necessary to use a larger instrument for mere purposes of inspection of the interior of the bladder or catheterizing the ureters. The instrument known as the urethral dilator, which also serves to measure the caliber of the urethra, is a solid cone of metal, having a large, strong handle at its base; it is three inches in length, and gradually increases in size from a diameter of 3 mm. at its blunt tip to 16 mm. at its base. A series of numbers placed at intervals on the surface of the cone indicate its diameter at several different points. The evacuator as used by Kelly is a small, hollow, perforated metal ball, connected by a slender rubber tube a foot or more in length with a rubber bulb. Somewhere in the course of the rubber tube a bit of glass tubing may be inserted, so that the operator can tell when the urine is being sucked out of the bladder. When using the knee-chest position for the examination the evacuator is rarely necessary. When the woman is examined upon her back the urine tends to gravitate away from the urethra and collect in a pool in the base of the bladder, and must occasionally be removed during the examination. Any simple aspirating device, such as will occur to the mind of any practical surgeon, may be used for keeping the bladder dry during the examination. A long, slender pair of mouse-toothed forceps are used to hold bits of cotton or gauze and to

wipe away adherent mucus, blood, or pus which may cover and obscure the mucous membrane. A long, slender probe with a large handle bent to nearly a right angle with the shaft of the instrument is convenient when searching for the mouth of the ureter, although a slender metal ureteral catheter may be used for the same purpose. The metal ureteral catheter is twelve inches in length, slightly curved near its blunt point, corresponds in the middle of its shaft to the diameter of a No. 7 sound of the French scale (2 mm. in diameter), and just behind its tip to a No. 4. There are three small eyes near the tip of the catheter. This instrument is often exceedingly useful, and may be made to engage in a ureteral orifice which is stric-

FIG. 82.—KELLY'S TUBE FOR EXAMINING THE INTERIOR OF THE FEMALE BLADDER AND CATHETERIZING THE URETER.

tured, or may be used to dilate the ureter at a higher point when a silk instrument might fail to pass. It is convenient to have one or more of these catheters constructed of some flexible metal, such as tin. Solid ureteral bougies, 2 mm. in diameter, having a blunt point constructed either of flexible metal or of hard rubber, are sometimes useful in detecting the presence of stone in the ureter or for dilating a stricture. The metal ones are usually made twelve inches in length with an enlarged handle; the long ones for passing up to the kidney are made twenty inches in length. For the purpose of detecting stone these bougies may be tipped with wax, so that the contact with the stone will make scratch marks upon the surface of the wax visible when the bougie is withdrawn.

FIG. 81.—LONG AND SLENDER MOUSE-TOOTHED FORCEPS FOR HOLDING PLEDGETS OF COTTON OR GAUZE USED TO WIPE AWAY PUS, BLOOD, OR OTHER MATERIAL WHILE CATHETERIZING THE URETERS OF THE FEMALE THROUGH KELLY'S TUBES. (Kelly.)

For dilating strictures of the ureter Kelly also uses dilating catheters of metal ten inches in length, in sizes from 2½ to 6 mm. in diameter. The metal catheters are conveniently constructed, like a Thompson's searcher, with a flat surface on the handle, indicating the direction of the tip of the catheter, ending in a small, curved tube, with a little metal plug, such that the flow of urine from the ureter may be stopped temporarily if desired. In inspecting the interior of the bladder or catheterizing the ureters of the female by Kelly's method, the patient should be prepared by a thorough evacuation of the bowels, the external genitals should be thoroughly cleaned and disinfected, as for a surgical operation. The patient should empty her own bladder in the squatting or sitting position immediately before the examination.

In very nervous patients, in young girls, in case the operator is inexperienced, or where the urethra appears very narrow and to require considerable dilatation, the examination may be under a general anesthetic. The application of a ten-per-cent cocain solution, introduced into the urethra by means of Ultzmann's drop syringe, followed by the introduction of a pledget of cotton into the urethral orifice, saturated with the same solution, and left in place ten minutes before the examination is made, is usually sufficient to prevent undue pain and suffering. One of two positions may be chosen for the examination, according to the peculiarities of the individual case: If the patient

FIG. 83.—URETERAL PROBE FOR SOUNDING THE URETER IN THE FEMALE. (Kelly.)

is distinctly stout, the knee-chest position will usually be necessary; otherwise the bladder will not properly distend with air. If the patient is thin, the lithotomy position, with the buttocks elevated from ten to twelve inches above the surface of the examining table, by means of suitable cushions or by tilting the table to a sufficient degree, will give sufficient distention of the bladder. In either of these positions, if the patient is properly placed, the abdominal viscera tend to gravitate toward the diaphragm, and after the speculum is introduced into the urethra and the obturator withdrawn, the bladder distends with air by atmospheric pressure.

Kelly recommends that if the bladder does not distend, and if the patient is unable to stand the fatigue and the discomfort of an examination in the knee-chest position for a considerable time, first placing her in the knee-chest position, introducing a small speculum, so that the bladder distends with air, withdrawing the speculum, turning the patient over into the dorsal position, and then making the examination. It is desirable during the change of posture to keep the hips elevated. The knee-chest position is the one which renders the examination easiest for the surgeon, and insures the distention of the bladder with air. The patient may be held in this position by assistants, the most comfortable way, or if she be under a general anesthetic a suitable

harness attached to uprights at the foot of the operating table supports the abdomen and the buttocks respectively. It is important to keep the buttocks as high as possible, and the head and face as flat upon the table as may be. The surgeon then proceeds with the examination, using all aseptic precautions, such as would be used in a surgical operation: Sterilized instruments, sterile rubber gloves, etc. Lubrichondrin, "K-Y," or some other Iceland-moss preparation, sterilized, is the best lubricant for the instruments. In most cases before introducing the speculum it will be necessary to dilate the urethral orifice with the conical dilator. This is the narrowest part of the female urethra. The remaining portion usually dilates very readily, and the urinary meatus once passed the speculum glides easily into the bladder. The conical dilator is introduced gently into the urethra, and its caliber noted. In some instances the instrument passes in readily to a diameter of 8 or 9 mm., and in these cases no further dilatation is necessary. In others it will be necessary by a gentle boring motion to stretch the urethral orifice up to the size of speculum which the surgeon intends to use. An inexperienced operator usually finds it necessary to dilate the urethra quite widely, perhaps to the size of 12 or 13 mm. With experience he will learn to make his examination, and to catheterize the ureters with a smaller instrument. It should be borne in mind that the manipulations are to be made gently, and that the urethra should not be dilated more than is absolutely necessary, since it is possible to lacerate the mucous membrane, and even to tear the muscular wall of the urethra. I have seen one or more cases in which urinary incontinence resulted, requiring a plastic operation for its cure. Having dilated the urethra to a sufficient extent, the surgeon takes a speculum of suitable size with its obturator, holding the cylindrical portion of the instrument between the index and middle fingers of the right hand, the handle is grasped lightly by the fourth and fifth fingers while the thumb holds the obturator firmly in place. The point of the instrument, being properly lubricated, is gently introduced into the urethra, and pushed forward in a gentle curve underneath the pubic arch into the bladder. The

FIG. 84.—EXAMINING THE BLADDER THROUGH KELLY'S TUBE PREPARATORY TO CATHETERIZATION OF THE URETER, THE PATIENT IN THE KNEE-CHEST POSITION.

speculum is then held firmly in position by the handle while the obturator is slowly and gently withdrawn; air then rushes in and dilates the bladder. If air fails to enter, the surgeon will usually find that the patient is improperly placed. If in the knee-chest position, the head and shoulders will be found too high, or the patient will have arched her back instead of letting it sink. The light from the electric headlight or head mirror is then thrown through the speculum into the bladder, and the surgeon by gently moving the speculum from side to side, and alternately depressing and elevating the handle of the instrument, readily passes in review the interior of the organ. In the knee-chest position, when filled with air, the mucous membrane of the bladder is pale pink or dull white; the large blood-vessels, arteries, and veins may be seen here and there embedded in or beneath the mucous membrane. Ridges in the mucous membrane passing irregularly here and there in either side of the bladder indicate the position of the muscular bundles of the bladder wall. In this position the trigonum and urethral orifice are brought into view by depressing the handle of the instrument and elevating its point. This portion of the bladder is always a little redder than the rest of the organ.

When the trigonum has been brought into view one or other of the ureteric mouths may appear at once. In most instances it will be necessary to rotate the speculum to an angle of from 15 to 20 degrees from the middle line before the mouth of the ureter on either side is brought into view. The position of the ureter mouth will usually be indicated by a slight eminence shaped like a truncated cone, pink in color, in the center or inner side of which is the ureteral orifice. This may appear like a delicate transverse line or slit, or as a little rounded pit on one side of the elevation. The mucous membrane around the ureteral orifice is a little paler than the surrounding elevated area. If the speculum be held still, and the ureteral orifice kept in view, little gushes of urine will be seen escaping from it at intervals of from fifteen to thirty seconds or more. In order to locate the ureters the surgeon may bear in mind the fact that the trigonum of the bladder forms a triangle, two of the angles corresponding to the mouths of the ureters, the third and anterior one to the internal urethral orifice. This area is about an inch wide at its base and three quarters of an inch long on its sides. Therefore, in order to find the orifices of the ureters, the speculum should be withdrawn until the internal urethral orifice begins to close over its end. It is then pushed into the bladder about half an inch, and rotated from twenty-five to thirty degrees to one side of the middle line, and in the knee-chest position the handle is depressed, so as to bring the base of the bladder into the field of vision. The orifice of the ureter will then be found just in front of the open end of the instrument in the majority of cases.

When an examination of a patient is being made in the knee-chest position, it sometimes happens in slender young women that the bladder becomes so greatly distended with air that its base rises into the hollow of the sacrum, and can only be found by the surgeon with difficulty or not at all. Under

these circumstances the simplest measure is to change the position of the patient, placing her upon her back with the hips elevated. The mouth of the ureter, having been located either by sight or by holding the speculum firmly in the left hand over that area of the bladder where the ureter ought to be, and with a probe or metal catheter gently pushing the point of the instrument upon the bladder wall here and there until it engages in the ureteral orifice, the surgeon, in order to catheterize the ureter, uses one of the flexible silk catheters elsewhere described. For ordinary purposes a catheter twelve inches in length is the most suitable, very long catheters, twenty inches in length, being only used when it is desired to pass the instrument up to the renal pelvis. The aseptic catheter containing its wire stylet is gently engaged in the orifice of the ureter by introducing it through the speculum with the right hand. It may be pushed in from three to five inches. The stylet is then very carefully withdrawn, the catheter being held firmly in position. If it is desired to catheterize both ureters, the mouth of the other is then sought for, and catheterized in a similar manner. The catheters should be carefully labeled left and right. The speculum is then removed, leaving the catheters *in situ*, and their ends are introduced into two small bottles or test-tubes, placed between the thighs and held in position by pieces of sticking plaster attached to the skin, or by a suitable block of wood containing holes to fit the tubes or bottles, as the case may be. In females the catheters may be left in the ureters for a number of hours without detriment, or until a sufficient quantity of urine is collected for a physical, chemical, and bacteriological examination. The examination of the collected urines is made by the pathologist in the ordinary manner. Ten or 15 c.c. of urine is a desirable quantity to obtain from either kidney.

The following procedure described by Dr. Kelly is sometimes useful for securing urine from a suspected ureter and kidney, when, for any reason, such as severe infection of the bladder or other cause, it seems undesirable to introduce the ureteral catheter: The patient is placed in the knee-chest position and a speculum having its end cut away obliquely is used. The mouth of the ureter is identified by vision—i. e., from the escape of a gush of urine, and the end of the speculum is then held closely against the bladder wall, so as to include the ureteral orifice in its caliber. In this way with patience and a little time sufficient urine may be collected from that particular ureter to serve for examination, at least for bacteriological and microscopical purposes.

In regard to catheterization of the ureters as a diagnostic measure, it may be said that it is generally regarded at the present time as the most certain method of determining the functional activity of each kidney. The only real objections which can be urged against it are the possibility of carrying infection from the bladder into a normal ureter, and thus infecting a healthy kidney. Although this objection seems a very valid one, and has been much spoken of by those who are not in favor of catheterizing the ureters, yet as far as I am aware such infection has very rarely been proved. Other objections are

that ureter catheterization through the electric cystoscope requires great skill and much practice for its successful accomplishment, and must therefore always remain in the hands of specialists; that the apparatus is costly and difficult to keep in order, and that in a certain proportion of cases, owing to prostatic enlargement, or of chronic cystitis, with thickening and other changes in the mucous membrane of the bladder, or in tumors of the bladder, the operation may be impossible. The only very distinguished surgeon who has made a specialty of the surgery of the kidney, and who at the time he published his extensive work ("Surgical Diseases of the Kidney and Ureter"), in 1901, opposed ureteral catheterization as a routine measure, upon a number of grounds, is Henry Morris, of London. Whether he still entertains serious objections to the method, I know not.

The Method of Obtaining the Separate Urines by Instruments Known as Segregators—Namely, the Methods of Harris, Luys, and Cathelin.—These instruments depend for the separation of the urines of the two kidneys upon the

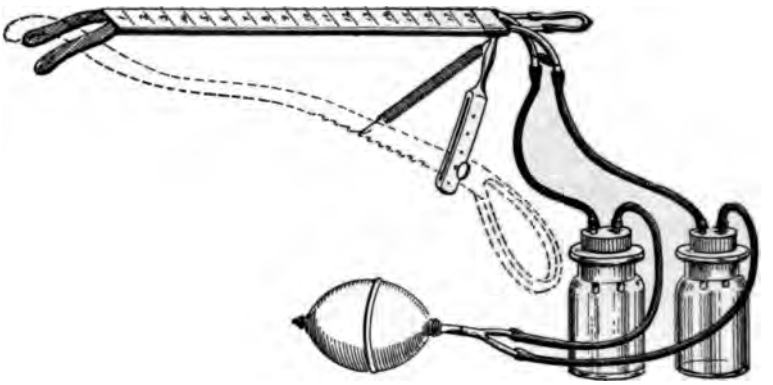

FIG. 85.—HARRIS'S URINARY SEGREGATOR.

creation within the bladder of an artificial dam or bar, thus separating the bladder into two lateral halves, from which the urine may be collected from either kidney. The instrument of Harris is at times very useful. I have used it with perfect success in a certain number of cases, and have failed entirely in others to obtain reliable results. It is useless for bacteriological purposes. It possesses the advantages that it is not costly; that it requires no especial skill on the part of the operator; that it may be used with good results in either sex; that it does not demand a general anesthetic, and is not very painful; that no danger exists of carrying infection from the bladder into the ureters. The instrument consists of two catheters, inclosed throughout the greater part of their length in a common sheath of metal. The intra- and extravesical terminal portions of the two catheters are exposed at either end of the inclosing sheath. The opposed surfaces of the intravesical portions of the catheters are flattened, so that when in contact the two form a cylinder having a double curve, and numerous small eyes connect the inner surfaces of the

intravesical portion with the interior of the catheter itself. The extravesical portions end in curved metal tubes. By means of these extravesical ends each catheter can be rotated independently upon its long axis, so that the intravesical portions can be separated and so rotated that each catheter comes to lie upon either side of the median line of the instrument. The extravesical portions have tips which may be connected with small rubber tubes leading to two vials for collecting the urine of each catheter. The corks of the vials are perforated in two places, one for the reception of the rubber tubes leading from the catheters, the other for the attachment of another rubber tube leading to an aspirating rubber bulb. Another essential portion of the instrument consists of a long lever with a strong handle, and of a shape seen in the illustration.

The instrument is used in the following way: The patient lies in the lithotomy position, the bladder is emptied by an ordinary catheter and washed clean; the double catheters are introduced into the bladder closed; the extravesical ends of the catheters are then gently rotated outward until they make with one another an angle of from a hundred to a hundred and ten degrees. A similar rotation, of course, takes place in the intravesical portions, so that each catheter comes to lie upon either side of the middle line of the bladder. The catheters are then fixed in this position by means of a small spiral spring connecting the extravesical ends. The long lever is then introduced into the rectum of a male patient or into the vagina of a female, and is then attached by a suitable clamp to the common sheath of the catheters. By means of a long spiral spring the rectal or vaginal end of the lever is drawn rather strongly upward, so that it forms a ridge or fold in the middle line of the bladder between the ureters, with a deep pocket upon either side; in other words, a distinct

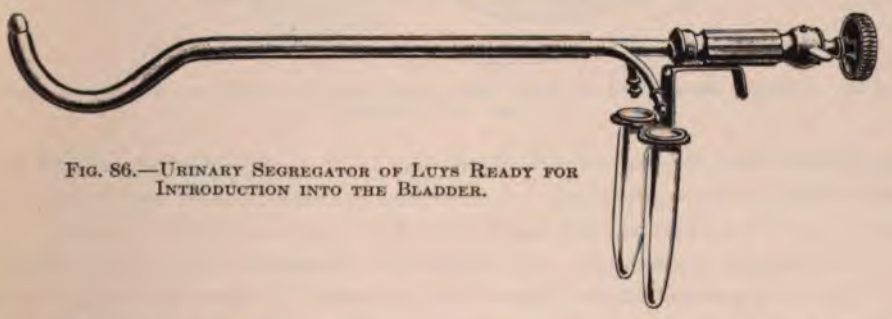

FIG. 86.—URINARY SEGREGATOR OF LUYS READY FOR INTRODUCTION INTO THE BLADDER.

watershed, so that the urine from one ureter collects in one pocket, from the other in the pocket upon the opposite side. By means of the suction bulb attached to the before-mentioned bottles the urine is sucked out of the bladder gently from time to time, and is collected in the two bottles, representing the product coming from the right and left ureters respectively. Although the description of the instrument is difficult, the illustrations render the method of its operation entirely plain, and its use is extremely simple. In the hands

of a number of observers the instrument has given very satisfactory results. During its use the efficiency of the apparatus may be determined by injecting a small amount of colored fluid into one catheter. The instruments of Luys and of Cathelin are very highly recommended by Hartmann and by Guyon respectively. The instrument of Luys consists of a combination of two catheter-shaped tubes side by side; between them is a metal partition. On the concave surface of the intravesical portion of the instrument there is a little chain, so arranged that by tightening it it comes to form the chord of an arc, thus filling out the concavity of the catheter. The entire middle partition, including the chain, is covered by a thin tube of India rubber, and when the chain is tightened a thin sheet of India rubber is spread out within the bladder by the chain in such a manner as to cause a median partition separating one half of the bladder from the other. The instrument having been introduced in

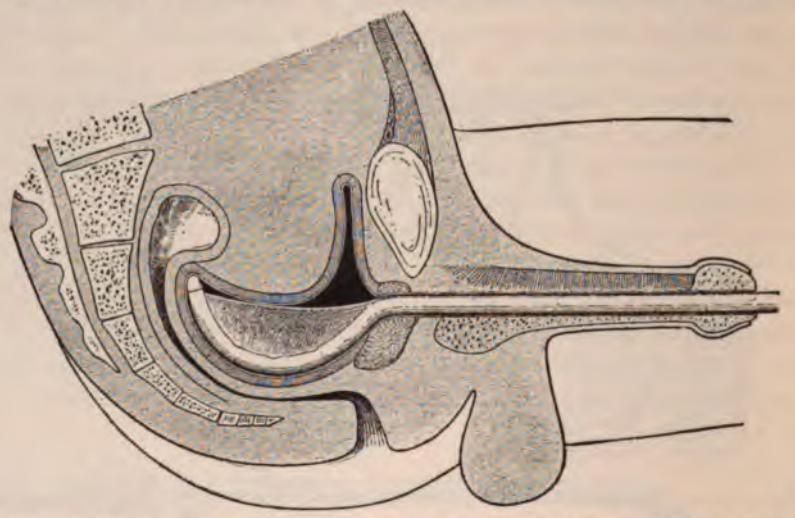

FIG. 87.—URINARY SEGREGATOR OF LUYS INTRODUCED INTO THE BLADDER. The central diaphragm has been extruded.

the bladder and the partition created, the urine is collected separately by the two catheters from either side. I have had this instrument used upon a number of my own cases in the hospital without very satisfactory results.

In *Surgery, Gynecology, and Obstetrics*, December, 1908, B. S. Barringer —"The Comparison of the Total Urea Excreted by Each Kidney in Surgical Diseases of These Organs"—reports forty cases in which he used the Luys separator with satisfactory results.

The instrument of Cathelin seems to be constructed upon more correct principles. It consists of a catheter-shaped metal instrument divided into two separate tubes by a metal partition, having each a separate orifice at the junction of the straight with the curved portion of the catheter shaft. A slit or groove exists on the convex surface of the curved portion of the instrument from which a loop of spring wire may be extruded to any desired extent,

cording to the capacity of the individual bladder previously determined by injection of water. The wire loop is covered by a thin layer of India bber, which is stretched over it, thus forming a complete diaphragm, which parates the bladder into two equal parts (see Fig. 88). An eye exists on ther side of the instrument, through which a slender silk catheter may be troduced into the corresponding portion of the bladder, and the urine col-

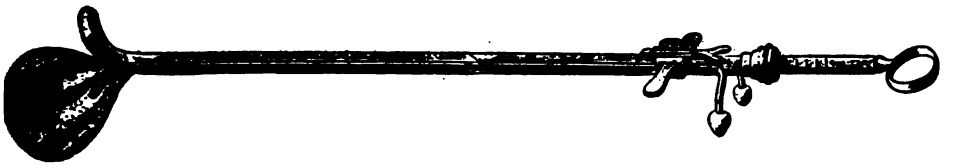

FIG. 88.—URINARY SEGREGATOR OF CATHELIN.

lected from either side. The instrument is highly recommended by many surgeons who have used it. It possesses the advantages, according to its inventor, of painlessness, and the fact that the size of the rubber diaphragm may be varied to suit the capacity of the individual bladder. At the present time the instrument enjoys in New York a very considerable popularity. The instrument may be used in a very small bladder.

CHAPTER XI

CONGENITAL ANOMALIES OF THE KIDNEY AND URETER

DURING embryonic life arrested or faulty development of portions of the genito-urinary tract eventuates in anomalies of the adult kidney and ureter. These are of rather frequent occurrence and great practical interest to the surgeon. No serious surgical procedure upon the kidney can be properly undertaken without giving the possibility of such variations from the normal due consideration. It is important that the character and frequency of these anomalies should be known to every surgeon, and since the variations occur as the result of faulty or arrested development in the embryo, and appear in the adult as correlated variations of definite types, they can only be properly understood by a study of the development of the genito-urinary tract. The recent work of Dr. George S. Huntington,[1] Professor of Anatomy, Columbia University, in this field has done much to render clear the mode of production and correlation of anomalies of the kidney and ureter. Through his kindness I am permitted to quote from one of his lectures on this topic, and to reproduce his diagrams and drawings.

HISTORY AND DEVELOPMENT OF THE KIDNEY AND URETER

A brief outline of the history and development of that portion of the genito-urinary system which concerns us here is as follows:

The permanent or metanephric renal system arises first as an outbud from near the cloacal termination of the primitive amniote pronephric duct, which, subsequently becoming associated with the mesonephros or Wolffian body as the Wolffian duct for a considerable period of embryonic development, is finally destined, after sexual differentiation, to become connected with the male sex-gland as its efferent duct and to be carried into the adult organization of the male as the canal of the epididymis and vas deferens, while in the female it undergoes degeneration and disappears with the exception of insignificant embryonic remnants.

Fig. 89 shows in schematic reproduction the general embryonic field involved in the subsequent development of the Wolffian and metanephric renal systems. The intestine terminates in a blind end, the caudal gut; the immediately preceding enlargement is the primitive cloaca, while from the ventral cloacal wall proceeds

[1] Reprinted from "The Harvey Lectures," Series II, 1906–'07. Copyright, 1908, by J. B. Lippincott Company.

the allantois. The cloaca and allantois are to share in the development of the bladder, urachus, and urethra, and the changes are initiated by the establishment of a connection between the mesonephric or Wolffian duct and the cloaca, the opening being situated in the lateral cloacal wall nearer the ventral midline and approximately midway between the cephalic and caudal end of the cloaca. The duct bears no relation to the allantois. In human embryos of about the fourth week (4.3 mm.) the cloaca reaches the highest stage of its development and is very capacious. Subsequently the cloacal space diminishes, being assigned ventrally to the bladder and allantois, dorsally to the gut, by the descent, from the cephalic pole caudad of the sharp fold at the intestinal entrance.

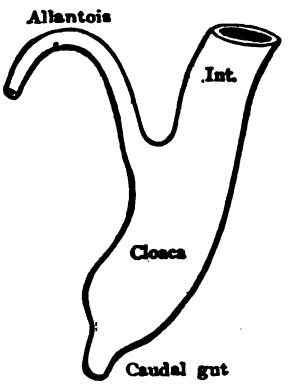

FIG. 89.—SCHEMA OF EARLY STAGE OF CLOACAL FORMATION, JUST BEFORE WOLFFIAN DUCT HAS REACHED THE CLOACA. (Human embryo of about 4 mm.)

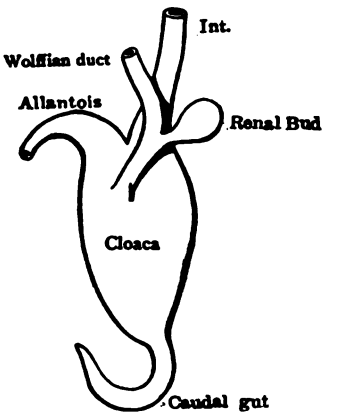

FIG. 90.—SCHEMA OF CLOACAL DEVELOPMENT, AFTER ENTRANCE OF WOLFFIAN DUCT AND ORIGIN OF RENAL BUD FROM ITS DORSAL WALL. (Human embryo of about 5 mm.)

Fig. 90 shows the entrance of the Wolffian duct into the cloaca and the first rudiment of the permanent hind kidney or metanephros. This organ develops as an outgrowth, the *renal bud* or *renal blastema*, from the dorsal wall of the caudal end of the Wolffian duct near the latter's termination in the cloaca. The renal bud extends at first dorsad and slightly laterad to the termination of the Wolffian duct, then passes on its mesal aspect and grows from here cephalad into the indifferent mesodermic tissue lying ventral to the aorta. The blind extremity of the renal bud divides into a cephalic and caudal branch and becomes covered by a mass of specialized mesodermal tissue, the renal *mesenchyme*. The primary outgrowth from the Wolffian duct represents the future ureter, the point of bifurcation the adult pelvis of the duct, and the upper and lower primary embryonic branches furnish the adult cephalic and caudal primary calyces or the secondary divisions of the main pelvis. The differentiated and specialized mesodermal tissue of the renal mesenchyme yields in general part of the parenchymatous excretory system of the adult organ.

Fig. 91 shows the reduction of the cloacal space by the descent of the lateral folds, the development of the urinary bladder from the cephalic and ventral portion of the primitive cloaca, still carrying the implantation of the allantoic duct (urachus), and the more complete separation of the hind gut from the genito-urinary tract. The Wolffian or mesonephric duct, and the ureter or metanephric

duct, still open by a short common segment. The distal end of the renal bud shows the primary division into a cephalic (yellow) and a caudal (green) branch.

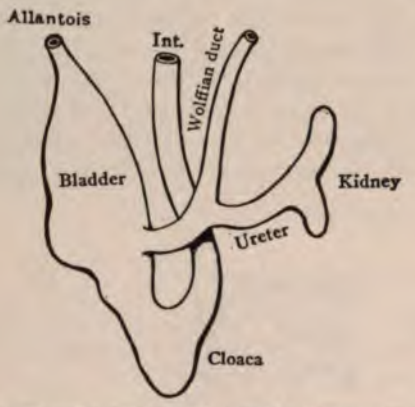

FIG. 91.—SCHEMA OF TERMINAL SPROUTING OF RENAL BUD INTO CEPHALIC AND CAUDAL PRIMARY BRANCHES. (Human embryo before 10 mm.)

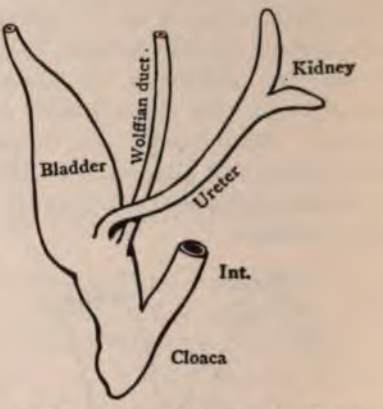

FIG. 92.—SCHEMA OF URETERIC AND WOLFFIAN DUCT RELATIONS AFTER INCLUSION OF THEIR PRIMITIVE COMMON TERMINAL SEGMENT IN THE CLOACA. The ureter passes to lateral side of duct and gains a separate cloacal opening. (Human embryo of about 14 mm.)

In Fig. 92 the segment common to the Wolffian duct and ureter in the early stages has disappeared, having been taken into the expanding ventral cloacal compartment from which the bladder and genito-urinary sinus are derived. The two ducts thus acquire separate and distinct openings. The ureter passes laterad to the Wolffian duct and enters what is to become the future trigonal angle of the bladder a little in advance of, or cephalad of, the termination of the Wolffian duct. The latter, as future vas deferens, descends further caudad to empty into that portion of the tract destined to furnish the prostatic urethra. At first the openings of the ureter and Wolffian duct are close to each other, in the relative position indicated in the schematic figure. Subsequently the narrow interval separating the two openings enlarges, possibly due to an unequal growth of the bladder segment involved, or to a descent of the genital ducts, the ureter terminating at a higher level and more laterally in the trigonal angle of the bladder, while the Wolffian duct descends caudad and mesad and ends, as the ejaculatory duct, in the floor of the prostatic urethra. The entire tract can therefore, after this stage has been reached, be divided into the following segments:

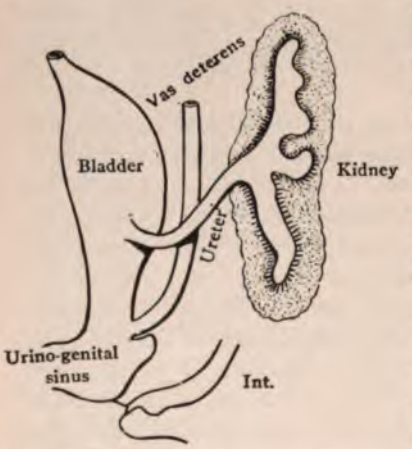

FIG. 93.—SCHEMA OF TERMINAL SPROUTING OF RENAL BUD INTO CEPHALIC AND CAUDAL PRIMARY BRANCHES. (Human embryo before 10 mm.)

1. Allantoic duct, urachus.
2. Urinary bladder, receiving the metanephric duct (ureter).

3. Urethra, in the narrower sense, from the termination of the bladder to the point of entrance of the mesonephric (Wolffian) duct, into the prostatic urethra.

4. Genito-urinary sinus, or urethra in the wider sense, from this point on the common excretory canal of both renal and sexual ducts.

These changes are indicated schematically in Fig. 93. The cloaca, as such, has disappeared, the hind gut having become entirely separated from the ventral or urogenital division. The descent of the testes would carry the vas deferens in the typical arch across the ureter, between the bladder wall and the terminal segment of the kidney duct. The ureter at its cephalic extremity has expanded the point of its primary branching into the dilatation of the adult pelvis. The primary cephalic and caudal branches (primary calyces, secondary pelves) show further buds, the secondary or terminal calyces, and lie embedded in the mass of the differentiated renal mesenchyme.

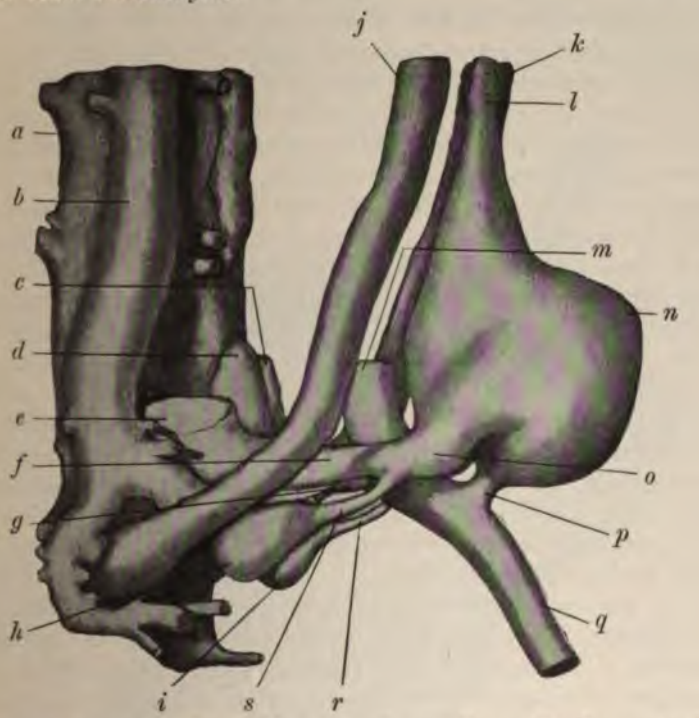

FIG. 94.—RECONSTRUCTION AFTER BORN'S METHOD OF CAUDAL END OF CAT EMBRYO OF 6.8 MM. X 50. (Columbia University Morphological Museum, No. 3101.) *a*. Aorta. *b*. Right post-cardinal vein. *c*. Cephalic pole of left kidney. *d*. Cephalic pole of right kidney. *e*. Cut surface of distal end of right Wolffian body. *f*. R. mesonephric (Wolffian) duct. *g*. Ant. division right post-cardinal vein. *h*. Caudal pole of right kidney. *i*. Caudal pole of left kidney. *j*. R. umbilical A. *k*. L. umbilical A. *l*. Duct of allantois. *m*. Intestine. *n*. Bladder. *o*. Common terminal segment of mesonephric (Wolffian) and metanephric (ureter) ducts. *p*. Remnant of connection between ventral and dorsal (intestinal) cloacal divisions, s. c. "Stalk of allantois." *q*. Caudal gut. *r*. Left ureter. *s*. Right ureter.

Fig. 94 shows in profile, viewed from the right side, the plastic reconstruction of the early development of the permanent kidney in a cat embryo of 6.8 mm. magnified 50 diameters, in a stage corresponding to the schema of Fig. 91. The right Wolffian body, still a very voluminous organ in this stage, is shown divided

near its caudal extremity to exhibit the renal metanephric bud situated on its mesal aspect and ventrad of the aorta. The ureter appears as an outgrowth from the dorsal wall of the Wolffian duct near its cloacal termination, turning dorsad to its engagement in the mass of the renal cellular mesenchyme. Wolffian duct and ureter possess a short and relatively wide terminal segment, already in the process of opening out to be included in the genito-urinary sinus. The end gut is still connected with the cloaca by a narrow channel, formerly described as the "stalk of the allantois," but the separation of the primitive urogenital and intestinal compartments of the cloaca has nearly been completed. The greater part of the ventral and cephalic cloacal division has been devoted to the formation of the urinary bladder, prolonged at the vertex into the allantoic duct (urachus). The umbilical (hypogastric) arteries cross the ventral division of the post-cardinal veins and laterad to the caudal pole of the Wolffian body and its duct, to converge from each side, with the urachus between, toward the umbilicus. The ureters are still connected with the *ventral* surface of the renal buds. The kidneys at this stage lie close together, their mesal surfaces only separated by a slight interval of indifferent pre-aortic mesodermal tissue. Subsequently they grow cephalad and dorsad, carrying, of course, the ureter with them in the same direction, and pass backward in their ascent to their final position on each side of the aorta, between this vessel and the post-cardinal veins. At one time, therefore, after the kidney proper has penetrated the cleft between the aorta and the post-cardinal veins, the ureters lie dorsad of the latter and emerge between them and the aorta in passing caudad and mesad to their termination.

Subsequently, with alteration in the great abdominal veins leading to the establishment of the usual type of the placental post-cava, the new channels form dorsad to the ureters, thus freeing the ducts, the terminal segments of the sex veins alone remaining as indicating the original pre-ureteric position of the primitive post-cardinal veins. The changes in the venous relations of the metanephros and ureter, as well as the early close apposition of the renal buds, will concern us presently in considering some types of congenital variation depending upon fusion of the two kidneys. The path of the so-called renal "migration" is probably to a certain extent determined under normal conditions by the shrinkage of the Wolffian bodies, these massive organs of the earlier stages affording by their atrophy and degeneration a line of less resistance to the advance of the permanent kidney. In part, also, this "migration" of the kidney, while finally locating the organ in its permanent position in the upper lumbar region, must be interpreted to some extent as the expression of unequal embryonic parietal growth, producing a relative displacement of the kidney cephalad. A process of this kind is, of course, subject to irregular, arrested, or misdirected development from various causes, which we can properly regard as the primary etiological factors of many of the congenital displacements and fusion variations of the kidneys presently to be considered. To continue, however, in the first place with the embryological conditions responsible for certain variants of the ureteric ducts, we find the developmental stages of the mammalian type just described well illustrated by the adult organization of the corresponding structures in some of the lower vertebrates. Any number of examples, showing all possible stages in the process of final assumption of the mammalian form of the genito-urinary tract, can be cited as illustrations drawn from the comparative morphological standpoint.

EMBRYOLOGICAL VARIATIONS IN THE KIDNEY AND URETER

Embryologically the variations of the kidney and ureter may be grouped nder:

1. Variations in the ureter.
2. Arrest of the development of the kidney, complete or partial.
3. Variations in migration.
4. Fusion variations.

(1) **Variations in the Number and Termination of the Ureters.**—Among the most interesting and important variations in the genito-urinary tract are those affecting the ureters.

The following congenital anomalies are observed:

Double ureter with abnormal opening.

(*a*) In the bladder, in an abnormal position, with a narrow orifice, or

(*b*) In the prostatic urethra.

(*c*) In the ejaculatory duct, seminal vesicle, or vas deferens.

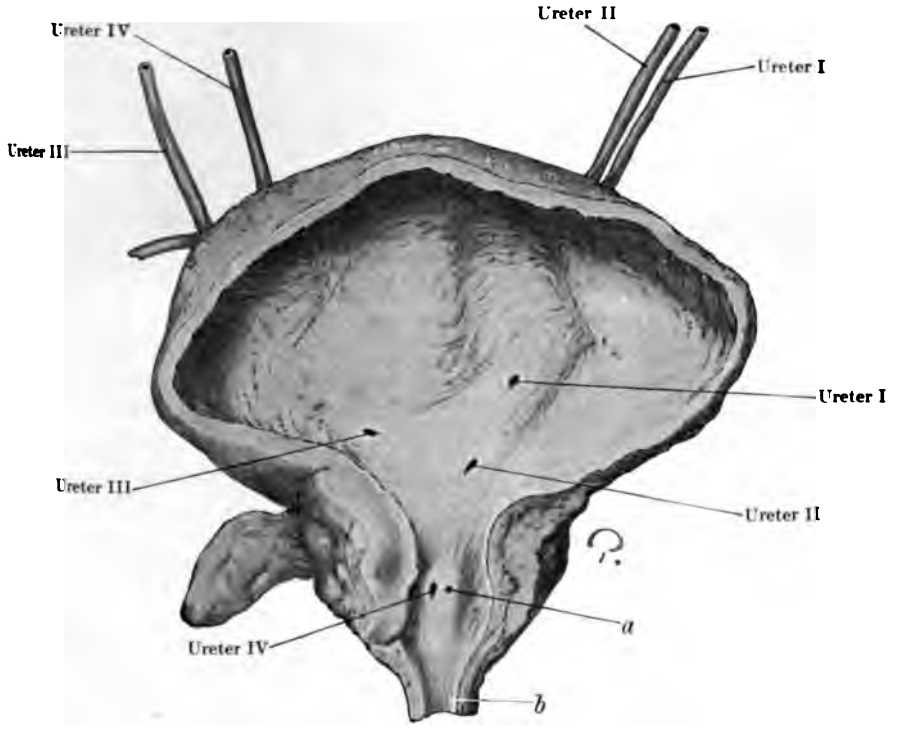

FIG. 95.—ADULT HUMAN. Bilateral complete ureteric reduplication. Bladder and prostate. Ventral view. (Columbia University Morphological Museum, No. 2029.) *a*. Opening of prostatic utricle. *b*. Membranous urethra.

In the following quotation from Huntington the mode of production of several of these variations is clearly explained. Practically the subject is so important that I believe no apology is needed for reproducing his remarks.

Permit me now to proceed at once to the demonstration of a typical adult human variation of the ureters, which illustrates one of the possibilities included within the common developmental scheme already outlined and on the hand of which we can at the same time consider certain minor and less extensive ureteric variations produced by disturbances in the normal process of development.

Fig. 95 shows the ventral, and Fig. 96 the dorsal aspect of the bladder, prostate, vasa deferentia, seminal vesicles and ureters in an adult male subject, forty-eight years of age, and Figs. 97 and 98 illustrate schematically the arrangement of the variant ducts of the two sides.

Each kidney in this individual gives rise to two distinct ureters, one proceeding from the cephalic, the other from the caudal portion of the gland. Each of

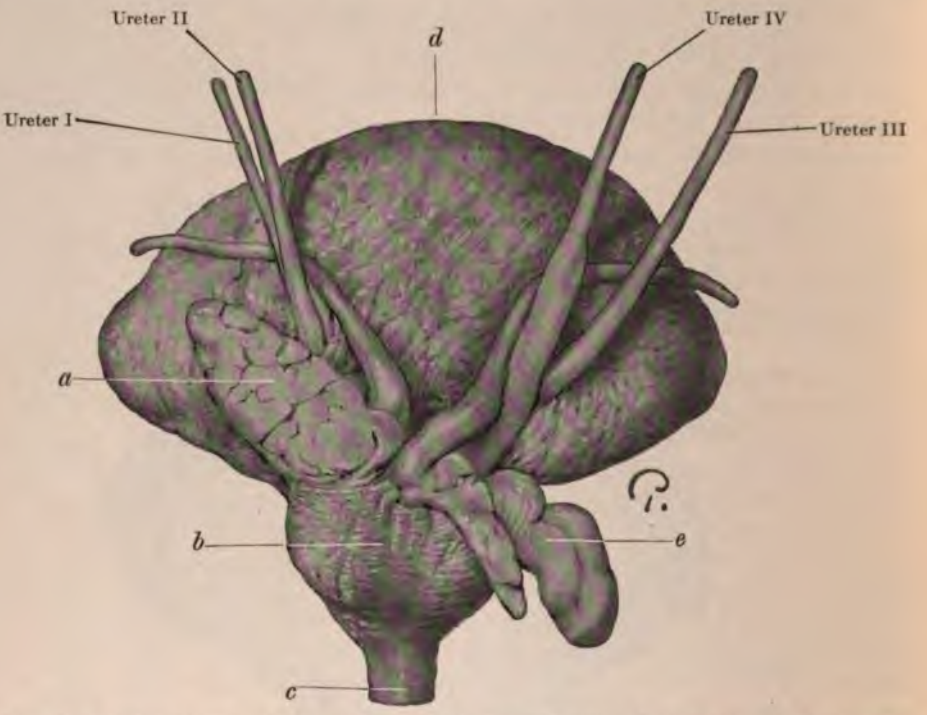

FIG. 96.—SAME PREPARATION. Dorsal view. *a*. Left seminal vesicle. *b*. Prostate. *c*. Membranous urethra. *d*. Bladder. *e*. Right seminal vesicle deflected to show course of variant ureter.

the four resulting ducts remains completely distinct throughout its entire course, terminating by a separate orifice and thus furnishing four separate ureteric communications with the genito-urinary tract.

The ducts proceeding from the left kidney, ureters I and II of the preparation, and in the schematic Fig. 97, empty into the bladder, ureter I, from the caudal portion of the left kidney, opening at the left angle of a somewhat distorted trigone, ureter II, draining the cephalic portion of the gland, terminating in the dorsal vesical wall farther distad and nearer the urethral orifice.

Ureter III, from the caudal portion of the right kidney, opens at the right trigonal angle. There is a well-marked torus interuretericus between the vesical

orifices of the ureters I and III, directed from the former downward and to the right, with a rather distinct supra-ureteric vesical recess, above the trigonal base

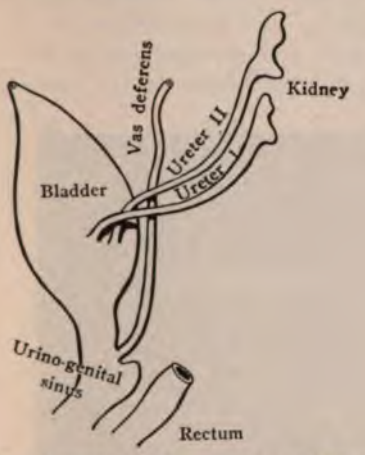

FIG. 97.—SCHEMA OF URETERIC AND WOLFFIAN DUCT RELATIONS ON LEFT SIDE OF FIG. 95.

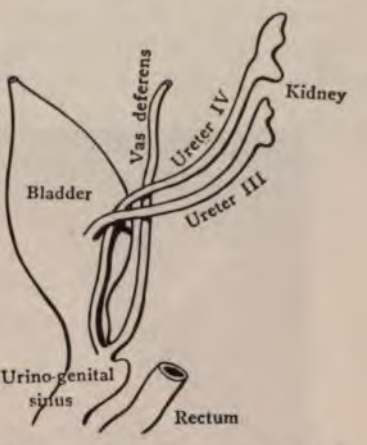

FIG. 98.—SCHEMA OF URETERIC AND WOLFFIAN DUCT RELATIONS ON RIGHT SIDE OF FIG. 95.

line. Below this level the modeling and general macroscopic structure of the trigonal area is normal, except that the double vesical ureteric openings of the left side have elongated the left trigonal line and have thus produced an oblique distortion of the entire field.

Ureter IV, draining the cephalic portion of the right kidney, passes laterad to the ampulla of the vas deferens, between the fundus of the bladder and the right seminal vesicle, to the upper border of the prostate, penetrates that body on the lateral aspect of the ejaculatory duct, and empties in common with the latter, in the floor of the prostatic urethra, on the right lip of the entrance into the prostatic utricle.

The variation just detailed calls for analysis and interpretation on the following features:

1. Increase in the number of kidney ducts.

2. The separate vesicle orifices of the two ureters of the left side.

3. The termination of one of the two right ureters in the bladder, while the second canal, in association with the sexual duct, empties into the prostatic urethra.

FIG. 99.—RIGHT ADULT HUMAN KIDNEY. Corrosion of ureter and renal vein. Dorsal view. (Columbia University Morphological Museum, No. 2105.)

1. INCREASE IN THE NUMBER OF URETERS.—Partial reduplication of one or both ureters is very commonly observed as a variation in the human subject, and

occurs normally in some of the other mammalia. In most instances the two ca proceed parallel to each other from the renal hilum caudad for a longer or sho distance and then unite into a single duct which enters the bladder in usual manner by a single orifice. Very frequently the reduplication of the ter modifies more or less extensively the structure and arrangement of the pe and primary calyces. Usually the lower of the two ducts is the more ca

FIG. 100.—ADULT HUMAN KIDNEYS. Incomplete unilateral ureteric reduplication. Corrosio right and left ureters of one individual. Dorsal view. (Columbia University Morphol Museum, No. 952.)

cious and develops the pelvis, as in the corrosion preparation shown in Fig. although the reverse may be the case, as in the left side in the preparation sh in Fig. 100.

In Fig. 99, a corrosion preparation of the right adult human kidney and r vein, the ureter presents a slight degree of reduplication, the two ducts uni into a single canal shortly after leaving the renal hilum. The cephalic duct, dr ing the upper kidney region, is of greater caliber, but nearly uniform, without tinct pelvic dilatation. The caudal, shorter and narrower ureter drains the mi and lower portion of the gland, and carries a large pelvis. The caliber is mark constricted just before union with the cephalic canal, and the pelvic dilatation be unduly developed by reason of this condition, in the sense of a slight hy nephrosis.

Fig. 100 is reproduced from a corrosion preparation of both ureters in the same individual. The left kidney presents typical normal relations of the duct. The single ureter possesses a uniform and moderately developed pelvis, which carries the typical cephalic and caudal main branches (secondary pelves or primary

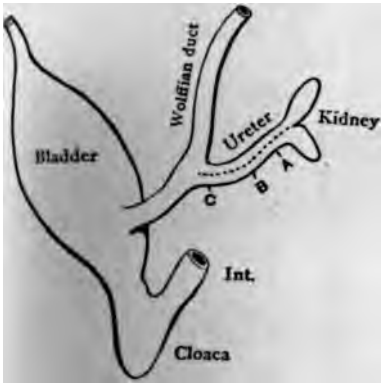

FIG. 101.—SCHEMA OF DEGREES OF URETERIC REDUPLICATION.

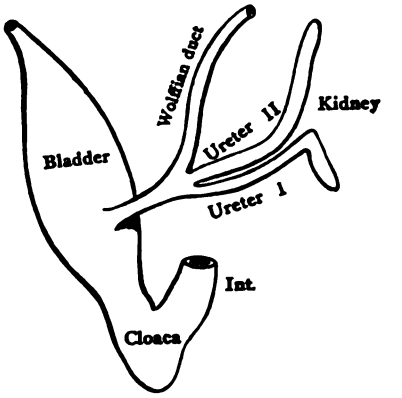

FIG. 101*a*.—SCHEMA OF COMPLETE URETERIC REDUPLICATION.

calyces), which in turn are provided with the usual number and arrangement of the cluster of terminal or secondary calyces. As is quite usual, the caudal of the two branches of the primary pelvis is the larger and carries a greater number of secondary calyces. The left kidney of this individual gave rise to two ureters which united into a single duct near the beginning of the lower third of the entire canal. The corrosion shows that the cephalic one of the two ureters is the main excretory canal of the gland. The pelvis and the primary and secondary derivatives are arranged typically and are of sufficient size and number to account for a normal kidney. The caudal and smaller ureter, draining the lower pole of the kidney, appears as an additional out-bud, carrying a cluster of supernumerary terminal calyces. If we recall the facts previously considered in connection with the development of the primitive metanephric renal bud from the terminal part of the Wolffian duct (Figs. 90, 91, 92, and 93) it is not difficult to recognize that these instances of partial reduplication of the ureter are to be interpreted as exaggerated forms of the normal embryonal type, in which the terminal sprouting into main cephalic and caudal divisions (Figs. 91, 92, and 93) has begun earlier than usual, at a point farther caudad and nearer the beginning of the renal out-bud from the wall of the Wolffian duct. We have seen that normally the main renal bud represents

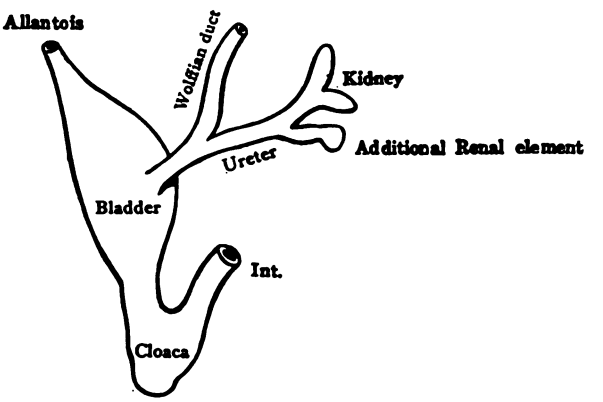

FIG. 102.—SCHEMA ILLUSTRATING DEVELOPMENT OF ADDITIONAL THIRD RENAL ELEMENT, POSSIBLE INTERPRETATION OF RIGHT URETER OF FIG. 100.

the future ureter proper, that the point of its terminal division into a cephalic and caudal sprout forms the site of the future pelvis, while the primary divisions are responsible for the typical dichotomous derivatives of the primary pelvis—i.e., the primary calyces or secondary pelves, which in turn develop the outgrowths forming the terminal or secondary calyces, receiving the collecting tubules (Fig. 93). If now the point of primary branching of the bud is moved farther caudad and nearer the junction of the metanephric outgrowth and Wolffian duct, the undivided segment of the bud, furnishing the adult ureter proper, will be shorter, the primary divisions consequently longer, extending as double ureters a variable distance beyond the renal hilum, and leading to the modifications of the pelvic structure and its derivatives already mentioned. Thus in the schema of Fig. 101 the dotted line between the cephalic and the caudal primary branches of the normal gland is prolonged caudad into the ureteric stalk of the renal bud, as indicating the path along which earlier branching will lead to one of the various degrees of reduplication of the ureters. Thus, if the terminal bifurcation is already established at the point *A*, the resulting adult condition will be the one seen in Fig. 99, where two short ureters leave the kidney to unite into a single canal a short distance caudad of the hilum. If the branching has already appeared when the out-bud reaches the level of point *B*, the resulting reduplication of the adult ureter will be more extensive and carried nearer to the vesical end of the duct, while, if the out-bud is double from its very inception, at the point *C*, where it starts from the Wolffian duct (schema, Fig. 101, *a*), the possibility is established of a completely doubled ureter with two separate vesical openings (as on the left side of the preparation shown in Fig. 95, *cf. infra.*), or of reduplication of the duct down to the bladder, union of the two canals in their intramural segment and hence a single vesical ureteric orifice.

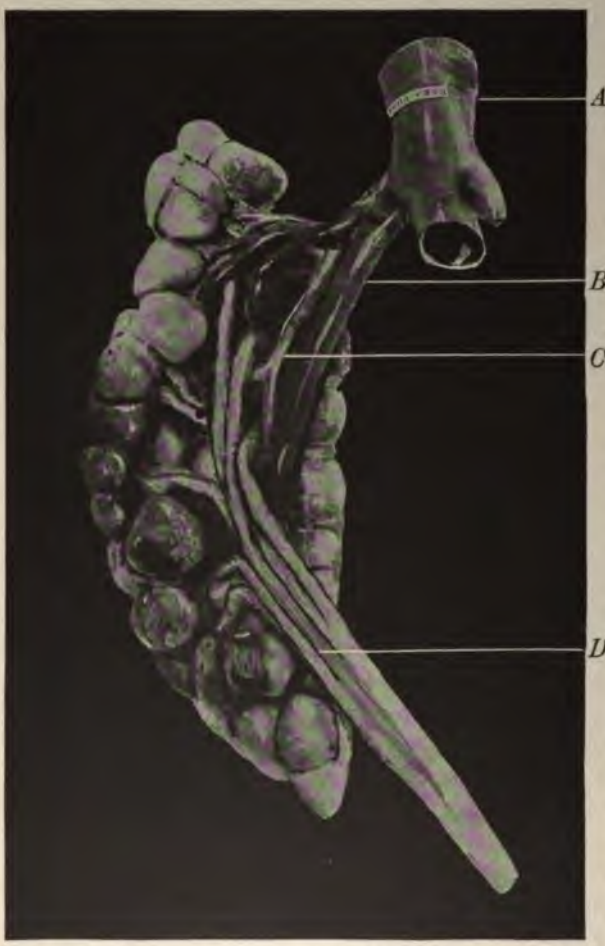

FIG. 103.—LUTRA CANADENSIS, OTTER. Left kidney. Injected. Formalin preparation. (Columbia University Museum, No. 3251.) *A*. Postcava. *B*. Renal vein. *C*. Renal artery. *D*. Multiple ureters emerging from renal hilum.

This interpretation would account for the greater number of ordinary instances of double ureters. In the light of the preparation shown in Fig. 100, however, we must admit a second type of ureteric reduplication in which the second canal represents, not an abnormally low or early bifurcatin of the main renal bud, but an additional third bud derived from the same. Thus in the left kidney shown in Fig. 100 the normal structure of the main (cephalic) ureter, with its perfectly formed pelvis and primary and secondary calyces, must be regarded as the result of typical development of the renal bud. The additional ureter (caudal) appears as a derivative from the main duct. Thus, to complete the schematic series, this condition would have to be represented as in Fig. 102, the red derivative representing an additional third sprout from an otherwise normally constructed renal bud, and responsible for the presence in the adult of the second or caudal ureter seen on the left side in Fig. 100.

FIG. 104.—LUTRA CANADENSIS, OTTER. Right kidney. Corrosion of ureter, renal artery and renal vein. (Columbia University Morphological Museum, No. 1969.) *A*. Renal artery. *B*. Renal vein. *C*. Single ureter produced by fusion of multiple separate ducts.

Increase in the number of renal buds, uniting into a single canal and opening by a single orifice in the bladder, is observed in some mammalian forms as the normal condition, and is to be interpreted in the manner above stated. An excellent example is afforded by the Canadian otter, *Lutra canadensis*. This carnivore possesses in the adult a permanently lobulated kidney, as shown in Fig. 103, with a leash of separate ureters which leave the hilum as distinct ducts and unite caudad into a single canal. Fig. 104 shows the corrosion preparation of the opposite (right) gland of the same animal in the dorsal view. The single ureter is formed by the confluence of seven individual ducts leaving the gland separately. This adult condition points, as stated, to a multiple terminal sprouting of the embryonic renal bud, instead of the typical dichotomous division normally characteristic of the human kidney.

2. COMPLETE REDUPLICATION OF THE URETER WITH TWO SEPARATE VESICAL ORIFICES.—Since, as stated, the short terminal segment common in earlier stages to Wolffian duct and renal outbud disappears subsequently by inclusion in the cloacal space and becomes incorporated in the future bladder and urogenital sinus,

the coincidence of the primary branching with the point of derivation of the bud from the Wolffian duct (*C* in Fig. 101, Fig. 101, *a*) will result in con reduplication of the ureter down to the bladder (schema Fig. 101, *a*), the two c either uniting in their intramural segments in passing through the bladder and then opening by a single vesical orifice, or remaining separate throu their entire extent and presenting two distinct vesical openings. This cond is rare as compared with the frequently observed partial ureteric reduplicatio

Fig. 105 shows the corrosion preparation of both ureters, and Figs. 106 and the bladder in the ventral and dorsal view respectively, of an individual who,

FIG. 105.—HUMAN ADULT KIDNEYS. Corrosion of ureters in case of complete reduplication o ureter. (Columbia University Morphological Museum, No. 1994.)

normal right kidney and ureter, presented a complete reduplication of the ureter, the ducts entering the left trigonal angle by two completely distinct teric orifices. The conditions correspond very closely to those already notice the same side in the bladder shown in Fig. 95. It is noteworthy that in all cases of complete reduplication the ureter draining the caudal part of the g

(ureter I) terminates at the higher of the two vesical orifices, while the cephalic duct (ureter II) extends farther caudad and opens at the lower of the two vesical orifices. In Fig. 106 the two left ureteric openings are more closely approximated

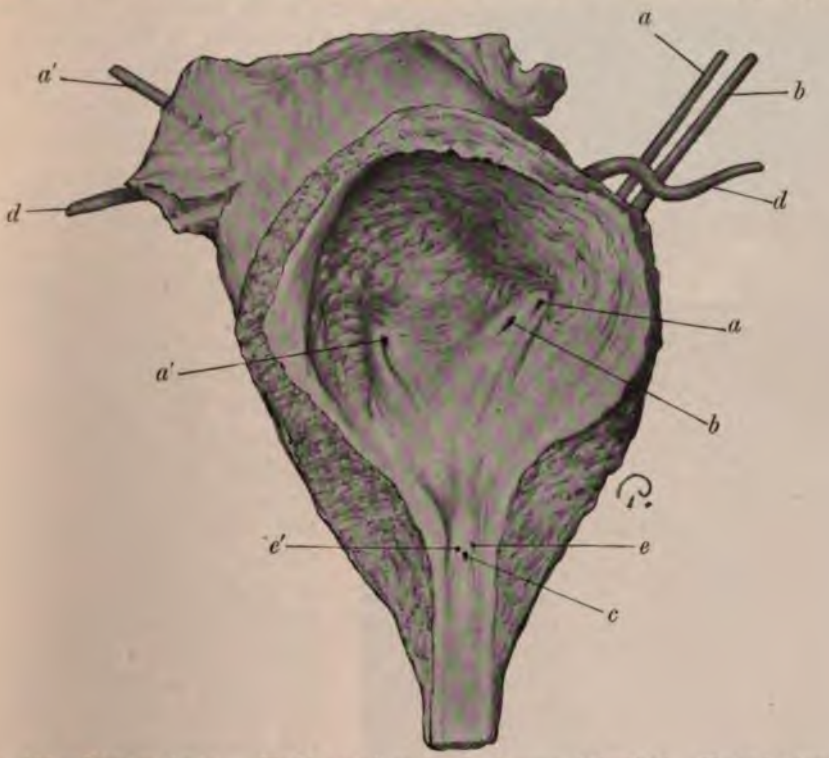

FIG. 106.—HUMAN ADULT. Bladder and prostate of same individual. Ventral view. (Columbia University Morphological Museum, No. 1302.) *a*. Ureter II. *b*. Ureter I. *c*. Prostatic utricle. *a'*, *a'*. Normal ureter. *d*, *d*. Vasa deferentia. *e*, *e'*. Orifices of ejaculatory ducts.

at the trigonal angle than in Fig. 95, but the same relation as regards the inverse portion of the kidney drained by the cephalic and caudal orifice is maintained in both cases.

The genetic interpretation, therefore, of the conditions presented by the preparation shown in Fig. 95 on the left side, complete double ureters with separate vesical orifices, is sufficiently clear and comprehensive.

3. COMPLETE REDUPLICATION OF URETER; VESICAL TERMINATION OF ONE DUCT, WHILE THE OTHER EMPTIES, IN ASSOCIATION WITH THE EJACULATORY DUCT, INTO THE PROSTATIC URETHRA.—If now we consider the arrangement of the renal ducts on the right side of the same individual, the genetic cause of the ureteric reduplication is of course the same which was operative on the left side—viz., early bifurcation of the renal bud at the point of its outgrowth from the Wolffian duct. The wide separation, on the other hand, between the ureteric terminations, the duct (ureter IV) from the cephalic part of the kidney opening in association with the ejaculatory duct into the prostatic urethra, while the duct from the caudal part of the kidney (ureter III) opens cephalad at the typical trigonal angle, requires interpretation on the following basis:

1. The early association of the ureter with the mesonephric Wolffian duct, as a direct outgrowth from the same, the two canals then terminating by a short common segment in a single cloacal opening. This is the permanent adult arrangement of metanephric renal and mesonephric sex ducts in the reptilian type, already noted in Fig. 108, and a temporary stage in the development of the mammalian embryo (Figs. 90, 91, and 94). Abnormal persistence of this embryonic condition in the adult mammal will lead to the permanent association of the two ducts, the ureter following the sex-duct and terminating in the prostatic urethra. Such instances are on record in the adult human subject.

2. In the present case we have to deal in addition with the complete reduplication of the right ureter in the sense already defined. We can, therefore, assume that developmentally, just after the expanding bladder area of the cloaca opened out to include the early common segment of the Wolffian duct and double metanephric bud or ureter within its own limits, this individual presented *on both sides* the relations of sex-duct and double ureters shown schematically in Fig. 109. The two possibilities of further development, leading to widely different adult conditions, now presented themselves. If in the further cloacal growth and differentiation of bladder, urethra proper, and genito-urinary sinus the typical separation of renal and sexual ducts involved in area *B*, between the double ureteric and the Wolffian duct openings, the unequal growth displacing the sex-duct caudad, while the ureteric openings shift relatively cephalad to the vesical fundus, then the resulting adult conditions would correspond to schema of Fig. 97, as actually occurred on the left side of the individual under consideration. If, on the other hand, the point of relative shifting involved the interureteric area *A*, the cephalic ureter (ureter I), draining the caudal part of the kidney, would obtain a vesical termination, while the caudal duct (ureter II), draining the cephalic portion of the gland, would follow the Wolffian duct or vas deferens in its relative downward displacement to the beginning of the genito-urinary sinus. In that case the ejaculatory duct and the displaced ureter II would open side by side in the floor of the prostatic urethra, the ureter laterad to the duct, on the lateral lip bounding the entrance into the prostatic utricle. This is practically the condition existing on the right side of Fig. 95. The fact that ureter and ejaculatory duct appear in this case to have a common opening, merely means a less complete separation of the displaced ureter

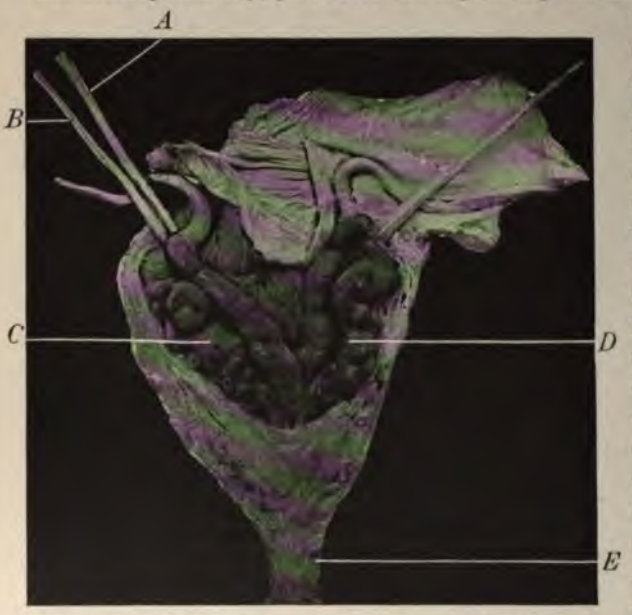

FIG. 107.—SAME PREPARATION. Dorsal view. *A*. Ureter II. *B*. Ureter I. *C*. Left seminal vesicle. *D*. Right seminal vesicle. *E*. Membranous urethra.

from the termination of the Wolffian duct; in other words (Fig. 110), the partial retention, for one half of the double renal bud, of the original short segment common to it and to the end of the Wolffian duct (Fig. 110). With further growth and expansion of the cloacal area *A* (Fig. 110) the separation between the vesical ureter I and the combined termination of Wolffian duct and prostatic ureter II would establish the actual conditions found on the right side of the individual.

That the above interpretation of this variation is correct becomes still further assured by the observation of Pohlman,[1] who gives an accurate account of two embryos with variant metanephric development. The first of these (embryo 175, of Mall's collection at the Johns Hopkins University, 13 mm.) presented two complete ureters arising from the left kidney. The duct from the upper part of the kidney lies ventrally, and is somewhat smaller than the one from the lower part of the gland. As the two ureters approach the urogenital sinus they curve around the Wolffian duct, the ventral one coming to lie close to the duct, the dorsal one being placed more laterally. The three openings are at the same level, and are arranged from the midline laterally as follows: Wolffian duct, ureter from the upper part of kidney (ureter II of Fig. 109), and then ureter from lower part of kidney (ureter I, Fig. 109). From this observation it is quite conclusive that the schematic condition shown in Fig. 109 may actually occur in the human

FIG. 108. — IGUANA TUBERCULATA, ♂. Ventral view of cloaca and genito-urinary tract. (Columbia University Morphological Museum, No. 1334.) *A*. Testes. *B*. Vas deferens. *C*. End-gut. *D*. Double bilateral penis, everted from cloacal pouches. *E*. Bladder. *F*. Cloacal orifice of bladder. *G*. Uro-genital papillæ, common cloacal orifices of vasa deferentia and ureters.

[1] A. G. Pohlman, "Concerning the Embryology of Kidney Anomalies." *Am. Med.*, vol. vii, 1904, p. 987.

embryo of 13 mm. as a variation, and in course of further development lead to one or the other of the variant adult arrangements seen in our instance (Fig. 95) on the left and right sides respectively.

The second observation of variant metanephric development recorded by Pohlman is in an older embryo, measuring 24 mm. (Embryo Piper-Keibel). In this

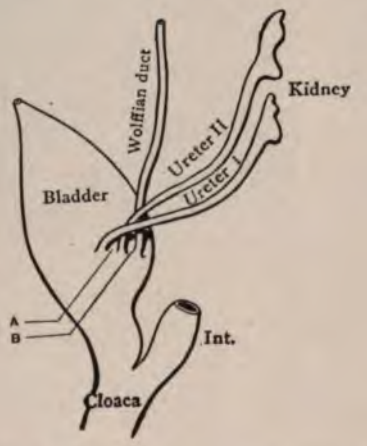

FIG. 109.—SCHEMA ILLUSTRATING POSSIBLE DEVELOPMENT IN CASES OF COMPLETE URETERIC REDUPLICATION, IN REFERENCE TO CONDITIONS ENCOUNTERED ON THE TWO SIDES OF PREPARATION SHOWN IN FIGS. 95 AND 96.

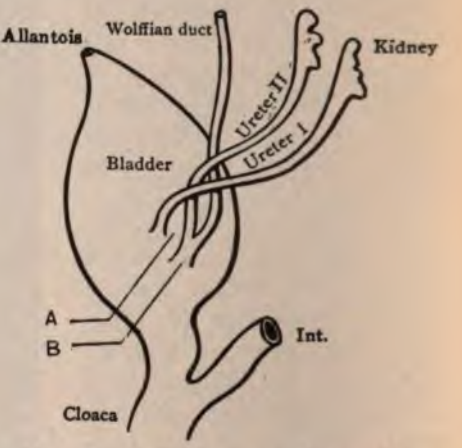

FIG. 110.—SCHEMA ILLUSTRATING COMMON OPENING OF ONE URETER AND EJACULATORY DUCT IN CASES OF COMPLETE URETERIC REDUPLICATION, THE OTHER KIDNEY-DUCT TERMINATING IN THE BLADDER. Explanatory of right side of Figs. 95 and 96.

preparation the relations of the two ureters are the same, excepting at the sinus. Owing to the greater development of the bladder the more lateral ureter has been carried higher up than the one situated medially. As Pohlman states in the paper quoted, this relation in the older embryo corresponds to the conditions found in the adult in cases of complete ureteric reduplication—viz., that the upper of the two vesical ureteric openings represents the termination of the duct draining the caudal part of the kidney and usually occupies the normal trigonal angle, while the ureter from the cephalic portion of the gland empties into the bladder farther down, somewhere between the first ureteric orifice and the opening of the ejaculatory duct (cf. Figs. 105, 106, 107, 95 and 96).

2. **Arrest of Development.**—The lobulated or fetal type of kidney is not uncommon, the organ being in other respects normal.

Henry Morris states that in 2,610 autopsies at the Middlesex Hospital, lobulation of both kidneys was noted in 4 cases, of one kidney in 5—i. e., once in 290 cases. The condition is of no pathological significance in itself. There is, however, reason to believe that such kidneys are more vulnerable to infection, notably to tuberculosis, than typically normal organs.

Numerous other deformities in the shape of a normally placed kidney have been observed, though such deformities are far more common in cases of faulty migration. Thus, Morris figures an hour-glass-shaped kidney, but

does not state whether or not it was normally placed. A normally placed, but discoid organ, having its hilum directed forward, from which the pelvis proceeds, is exceedingly rare. This deformity, with absence of rotation, is seen in many cases of arrested migration. Usually when the kidney has reached its normal site normal rotation is complete.

Absence of One Kidney.—Complete congenital absence of one kidney, when the renal bud has either not developed at all, or has remained in a rudimentary condition, is usually accompanied by a corresponding enlargement of the single normal kidney of the opposite side. Such a kidney may or may not present ureteric variations. "If, however, complete reduplication of the ureters of such a single kidney should occur, with congenital absence of the

Fig. 111.—Human Adult. Bladder, prostate, renal and sexual ducts. Ventral view in case of congenital absence of right kidney, adrenal right testis and vas deferens with appendages. (Columbia University Morphological Museum, No. 3252.) *A*. Blind vesical recess representing rudiment of right renal bud. *B*. Left ureter. *C*. Left vas deferens. *D*. Left seminal vesicle. *E*. Left ureteric trigonal orifice.

organ of the opposite side, both ducts would empty on the *same side*—as, e. g., the double ureters on the left side in Figs. 95 and 106—while the trigonal angle of the opposite side would either show no trace of ureteric orifice, or a short, blind recess representing the rudimentary and blighted renal bud. The bladder of such an individual, aged fifty-seven, with congenital absence of the right kidney and adrenal, is shown opened in the ventral view in Fig. 111.

The left kidney was unusually large and heavy, 5.5 inches in the greatest vertical and 2.75 inches in the greatest transverse diameter, but the gland and duct were in every respect normal, the ureter terminating at the left lateral trigonal angle. The corresponding angle of the right side presented, in place of the normal ureteric slit, a wide diverticular blind depression, 0.5 cm. in depth, the undeveloped rudiment of the right renal bud. Testis, vas, and seminal vesicle were absent from the right side, showing that the renal deficiency was based upon profound early defects in the development of the mesonephros and its duct, as well as of the sex gland of the right side. The testis and duct with appendages was normal on the left side" (Huntington, *loc. cit.*).

The great size of the single kidney in this case is the general, but not the invariable, rule, so that, *when a kidney of unusually large size is exposed by a surgeon, with intent to remove it, he should be absolutely certain of the presence and condition of the other kidney before proceeding with the nephrectomy.* According to the statistics of Morris, congenital absence of one kidney is observed once in 2,650 cases, 15,904 observations. The defect is more frequent upon the left side than upon the right, and in males than in females.

Imperfect and Rudimentary Development.—Imperfect and rudimentary development of the kidney is not infrequent, and may be of any grade. Morris states that 59 "atrophied," "small," "shrunken," or "wasted" kidneys were observed in 8,178 inspections. The kidney may be represented by a mere mass of fibrous tissue, or a series of cystlike cavities. In other cases, kidney tubules, but no glomeruli may exist. In the preceding groups there may be a ureter of diminished caliber, or a mere imperforate cord. In some cases the ureter is pervious upward from the bladder a certain distance, but closed above. In such a case a ureteral catheter might be introduced a certain distance; such a possibility therefore does not demonstrate the presence of a healthy kidney above. In other cases the kidney may be smaller than normal, and yet consist of normal kidney substance. Such kidneys may weigh from a drachm to an ounce or more.

Congenital defects of the bladder and genitals may coexist, as in the individual whose bladder is shown in Fig. 111. In the female the absence of the Fallopian tube and ovary have been observed, as well as congenital deformities of the uterus and vagina.

The following observation, made in the Roosevelt Hospital some years ago in the service of Dr. Charles McBurney, is of interest in this connection:

A young woman aged twenty-one years entered the hospital with the following history: She had suffered from frequent urination all her life, and had never been able to hold her water more than an hour or two. She entered the hospital with the signs and symptoms pointing very positively to advanced tuberculous disease of the kidney. Attempts to distend her bladder for purposes of cystoscopic examination failed utterly. Her bladder would contain not more than 1½ ounces of

aid. An incision was made into her peritoneal cavity and both kidneys were alpated. The left kidney was evidently extensively diseased. Palpation of the ight kidney seemed to indicate that the organ was normal. The left kidney was emoved and was found to be extensively tuberculous, though some kidney tissue emained, showing the lesions of chronic nephritis. The patient passed no urine fter the operation and died of uremia. At the autopsy it was found that the ight kidney was smaller than normal and contained no kidney tissue. It was made up of multiple cysts, some of them containing clear serous fluid, others a thick, white, pasty material. The right ureter was impervious. The bladder was represented by a small sac about an inch in diameter when contracted. There was a blind depression representing the right ureteric orifice. The uterus and ovaries were undeveloped and of the infantile type.

3. **Variation in Migration.**—Professor Pohlman, of the Johns Hopkins University, has made some very interesting observations on the chronology of renal migration in man.[1]

G. S. Huntington discusses these as follows:

His observations show that the Wolffian duct reaches and taps the cloaca in human embryos of about 4 mm., and that a little later, in embryos of 5 mm., the renal bud arises, at first from the dorsal wall of the Wolffian duct a short distance from its entrance into the cloaca, shifting subsequently to its lateral aspect. Before the 10 mm. stage has been reached the sprouting of the primary branches from the blind cephalic end of the renal bud begins, resulting in the establishment of the typical cephalic and caudal secondary pelves or primary calyces. In embryos of 14 mm. axial rotation occurs at the midlumbar level, the kidneys having reached this point in their passage cephalad from the second sacral level. This brings the hilum—up to this point directed ventrad—toward the median line. The normal renal level is attained in human embryos of 25 to 30 mm. (end of second month), after which the permanent vascularization of the gland takes place. This brief recapitulation of Pohlman's excellent history of human renal migration shows that interruption of the normal process may lead to the following embryonal variants.

Arrest of Migration, Usually Unilateral.—One of the kidneys is retained at a lower level than normal. This variation of displaced kidney always implies irregularities in the vascular supply. At whatever level the gland locates permanently, the vascular connections become established with the distal postcava and aorta or with the iliac vessels. If the arrest of migration occurred before the normal midlumbar level of rotation was attained, the resulting adult kidney will retain the early ventral position of the hilum, so frequently seen in kidneys located in the pelvis or near the sacro-lumbar junction. An example of this condition is shown in Fig. 112, of a discoidal right kidney arrested and permanently located at the right sacro-iliac joint. The ureter arises from the ventral surface, and the entire pelvis, as well as the primary branches of the duct, are extrarenal,

[1] A. G. Pohlman, "Concerning the Embryology of Kidney Anomalies," *Am. Med.*, vol. vii, 1904, p. 187.

typical hilum formation not having occurred. The vessels are derived from the large abdominal trunks at a point slightly cephalad of the actual position of the kidney, and hence descend to reach the cephalic pole of its ventral surface.

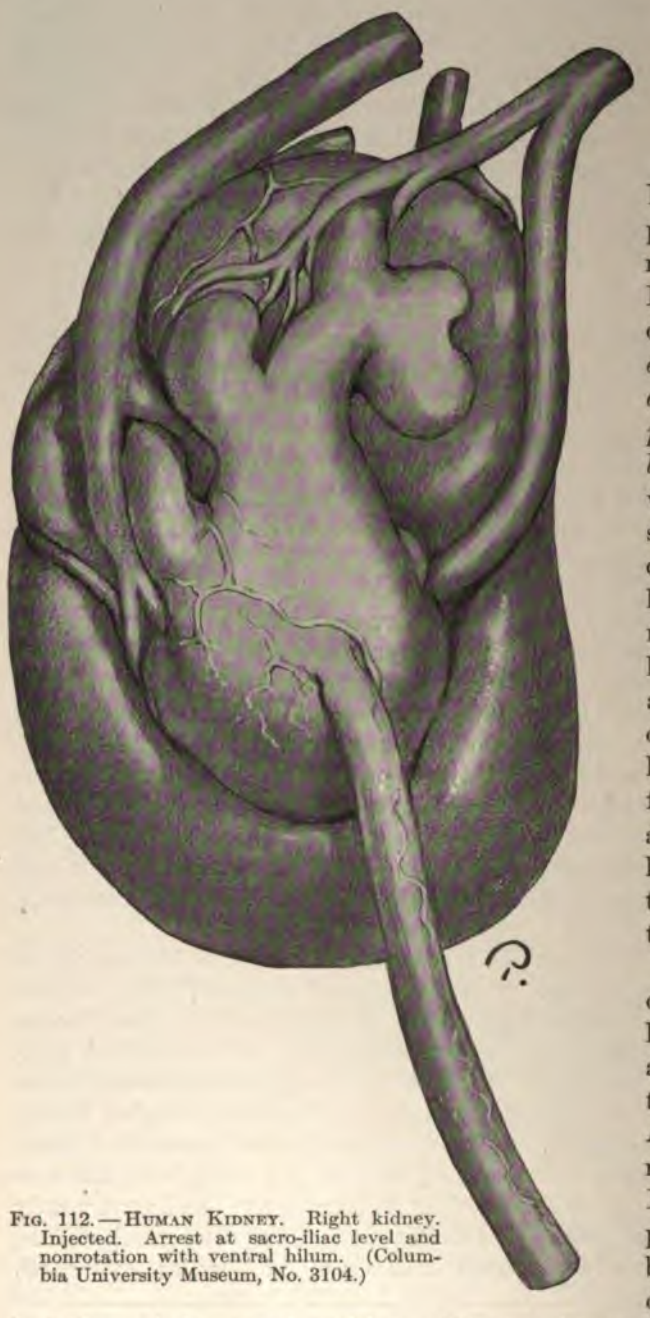

FIG. 112. — HUMAN KIDNEY. Right kidney. Injected. Arrest at sacro-iliac level and nonrotation with ventral hilum. (Columbia University Museum, No. 3104.)

CONGENITAL DISPLACEMENT OF THE KIDNEY.—Congenital displacement of the kidney is not a very rare deformity. Its recognition is, however, difficult. *A marked difference exists between movable and congenitally displaced kidneys, since the latter are firmly fixed.* It would, of course, be possible by palpation in exceptional cases to feel a kidney-shaped, discoid, or rounded solid tumor in the lower abdomen or pelvis; and if a styleted urethral catheter were arrested at a low point, it would be a fair presumption that such a tumor was or might be a kidney. Usually diagnostic errors are made in these cases.

As to the frequency of displaced kidney, the following statistical records are of interest. They are those of Henry Morris. Among 1,200 autopsies made at St. Bartholomew's Hospital, in more than 3 per cent of the cases one or both kidneys were found displaced more than one inch from their normal position. Extreme degrees of displacement are, however, rare. Thus, in statistics compiled from 12,768 autopsies made in Guy's

and the Middlesex hospitals, but 13 cases of markedly misplaced kidney were observed, or about once in 1,000 cases. Graser, quoted by Schede, collected 200 cases of congenital displacement of the kidney. In 12 both kidneys were displaced downward; in 103 the left kidney was displaced; in 85 the right; in 4 cases both kidneys lay on the right side, in 1 case both upon the left; whether these were examples of fusion variation was not stated. In 22 cases the displaced kidney lay opposite the promontory of the sacrum; in 15 cases entirely within the true pelvis. Intrapelvic kidneys may lie to one or the other side, or in the median line. Such may or may not create a mechanical difficulty during labor. Abnormally placed kidneys may become the seat of hydronephrosis from kinking or pressure upon the ureter or of infection.

Fig. 10, page 8, is a photograph which I took in Bellevue Hospital in 1907 of a patient of Dr. J. C. Ayer's.

A large, tense, cystic tumor existed in the right lower quadrant of the abdomen, moderately tender on pressure, and not at the time associated with urinary disturbances. No good history was obtained from the patient. Upon operation the tumor proved to be an infected hydronephrosis of a congenitally misplaced kidney.

A case of displaced kidney was observed in the service of Dr. Charles McBurney in the Roosevelt Hospital in 1894. The patient was a male child, aged fourteen years, with a distinct history of intermittent hydronephrosis extending over more than a year. The cystic tumor which formed during the attacks of retention was in the middle line of the belly, below the umbilicus. Upon operation it was found that the tumor consisted of the ureter and its pelvis dilated by urine to the size of a small adult head. The relations of the tumor to the ureter were such that a kink was produced at the junction of the ureter with its pelvis, totally occluding the former. The character of the cyst was not recognized at the original operation, or if recognized, its removal was considered at the time impracticable. Later the displaced kidney was removed. It proved to be the left kidney. It was nearly normal in shape, with its convex border directed downward, the hilum was directed upward and forward, the convex border of the kidney was adherent to the urinary bladder. The center of the cystic tumor formed by the dilated pelvis lay in front of the last lumbar vertebra. No record was made of the blood supply of the kidney. The patient made a good recovery.

In the year 1907 I fell into a diagnostic error on account of the presence of a congenitally misplaced kidney. The patient was a woman, aged twenty-seven years. It is interesting to note that she was the mother of three children, and that in each case labor was normal. She entered the hospital complaining of pelvic pain and of a more or less continuous discharge of blood from the uterus, which had existed for three months. Physical examination showed the presence of a rather large soft uterus. The left tube and ovary felt normal. Upon the right side and behind the uterus could be felt a firmly

fixed, tender, rounded mass, which seemed to be about the size of a small fist, and of firm consistence and smooth surface. Since the history of pelvic pain had extended over a period of three months, and had been combined with uterine hemorrhage, a probable diagnosis of extra-uterine pregnancy was made.

There had been no history of urinary disturbances. The patient was anesthetized and curetted. The character of the scrapings seemed to be that of a thickened uterine mucosa merely. The abdomen was then opened above the pubes—Pfanenstiel's incision. The uterus, tubes, and ovaries showed no abnormalities. The right side of the pelvic cavity was occupied by a kidney-shaped tumor, readily identified upon inspection and palpation as a kidney of nearly normal size and shape. It lay well within the pelvic cavity; the long axis of the organ was nearly vertical, and extended from the right iliac sacral joint downward, so that the lower pole of the organ was behind the uterus and right broad ligament. The hilum was directed anteriorly and a little to the left. The blood supply of the kidney was derived from the aorta and vena cava respectively. The vessels were rather long, and descended over the front of the organ to reach the hilum. The ureter was about three inches in length. It crossed the anterior surface of the kidney, and passed downward and forward to the bladder. A large vein emptied into the right external iliac vein. Except for the necessary examination to identify the kidney, as such, and to determine its relations, the organ was not interfered with. Palpation of the abdomen demonstrated the presence of a normally placed left kidney, and the absence of a kidney in the right loin.

The following case of congenital displacement of the kidney, with pyogenic infection of the kidney and ureter, came under my observation in 1907 in my service at the New York Hospital:

Pyogenic Infection of a Congenitally Misplaced Kidney—Nephrectomy.—The patient was a boy aged twelve, who was admitted to the New York Hospital September 22, 1906. He had been ailing during the preceding three months, and during much of the time had remained in bed. He had suffered from constant dull pain localized below and a little to the right of the umbilicus, made worse by motion. He had frequent and painful urination. The frequency and pain had gradually increased in severity, the pain being referred to the anterior urethra and glans penis. For the past few weeks he had had a daily rise of temperature and night sweats. He had also suffered from occasional attacks of vomiting and diarrhea. For the past six weeks it had been noted that his urine was turbid. His general condition had become notably worse during the past week, with increasing prostration.

Examination of the child showed him to be a slender and rather poorly nourished boy, moderately anemic. His leucocyte count was 16,500; polynuclears, 84 per cent. His temperature upon admission was 101.8; pulse, 128. His urine was very turbid, acid, contained a considerable quantity of albumin, large flakes of muco-pus, many renal cells, together with pus and red blood cells. Bacteriological examination of the urinary sediment showed the presence of numerous streptococci. Physical examination showed no abnormality of the thoracic viscera. The abdomen was moderately distended. There was general abdominal rigidity, fairly marked.

There was marked tenderness on pressure below and a little to the right of the umbilicus. Rectal examination with one finger was negative.

The child had been sent to the hospital by his physician with the probable diagnosis of vesical calculus. A searcher introduced into the bladder detected nothing. I was unable to arrive at any definite diagnosis, but thought that the patient had some acute inflammatory lesion in the lower part of his belly which merited an exploratory operation.

Under anesthesia the relaxed abdominal wall permitted one to feel a rounded tumor mass just below the umbilicus, deeply placed and immovable, apparently as large as a medium-sized orange, situated nearly in the middle line, but a little to the right. A median vertical incision was made, three inches long, beginning one inch above the umbilicus and extending downward. Upon opening the peritoneal cavity there was no evidence of peritoneal irritation. The tumor was situated behind the peritoneum; it formed a somewhat rounded eminence lying in front of the sacrum in the bifurcation of the vessels, a little to the right of the middle line. It consisted of two parts—a sausage-shaped fluctuating mass in front, with its long axis directed vertically, or nearly so, and a firmer disc-shaped tumor behind, about two and a half inches wide and an inch thick, nearly circular in outline, and firmly fixed. The lower border of this solid portion of the tumor was about two inches from the urinary bladder. Palpation of the right loin showed a large, normally placed kidney. No kidney could be felt in the left loin. It thus seemed probable that the retroperitoneal tumor was a congenitally misplaced kidney, and the condition of the urine seemed to indicate that the kidney and its pelvis were the seat of a suppurative inflammation.

The intestines were pushed upward and retained with gauze pads. The posterior layer of the peritoneum, overlying the tumor, was incised and pushed away on either side; it then became evident that the tumor was, indeed, a misplaced kidney. The fluctuating sausage-shaped portion in front—two and a half inches long and as large as a man's thumb—was the dilated ureteric pelvis, much thickened and evidently inflamed. From its center a short, somewhat thickened ureter led downward behind the bladder. Aspiration of the dilated pelvis showed that it contained pus. It was then determined to remove the kidney.

The organ was supplied by two sets of vessels. A larger set passed vertically upward to the aorta and vena cava respectively. A smaller set passed downward and to the left, and evidently was connected with the internal iliac vessels of the left side; these accompanied the ureter for a certain distance. The vessels were ligated with catgut. It was thought best to cauterize and ligate the ureter and to suture its orifice into the lower angle of the wound rather than run the risk of closing it and dropping it back in the abdomen. This proved to be a wise precaution, since some leakage did occur and slight infection of the lower angle of the wound, in consequence. There was quite a little oozing of blood from small vessels in front of the sacrum, torn across while enucleating the kidney. From the depth of the wound and the narrowness of the field it was found most convenient to check this oozing by a piece of sterile gauze packing, which was led out through the lower angle of the abdominal wound. The remainder of the wound was sutured in the ordinary way.

The patient's general condition remained good throughout the operation. During the first three days there was some distention of the intestines with gas, re-

lieved by enemata. Rectal irrigations of salt solution were given for four days. The quantity of urine passed after the operation did not vary much from twenty-four ounces daily. The character of the urine changed at once; the quantity of albumin diminished to a faint trace and the pus cells diminished to a small amount. The child became afebrile almost at once; all the septic symptoms disappeared. Appetite for food returned. The wound healed well, except that a small sinus remained at its lower angle which discharged a little thin pus. This soon healed and the child made a perfect recovery.

The kidney was disc-shaped, somewhat lobulated, but nearly circular in outline, two and a half inches wide and an inch thick. The ureteric pelvis was much dilated, thickened and inflamed. The cortex of the kidney contained numerous abscess cavities scattered here and there, though considerable healthy kidney tissue was present between them. The capsule of the kidney was somewhat adherent, but not notably thickened. As stated, abundant streptococci were found in the abscess cavities. A hematogenous origin of the infection seemed to be probable.

4. **Fusion Variations.**—The commonest variety of kidney fusion is the *Transverse Fusion of the Renal Buds with the Resultant Formation of Renal Tissue Ventrad of the Aorta and Post-cava.* "This variation, leading to the production of the relatively common "horseshoe" kidney in one of its forms, calls in its genetic interpretation for the assumption of coequal and symmetrical development of both renal buds, both attaining the same level at the same time, but fusing abnormally across the narrow, indifferent mesodermal zone, typically separating the caudal poles of the renal blastemata."

FIG. 113.—HUMAN ADULT. Caudal pole or "horseshoe" fusion of kidneys. Isolated preparation with nearly normal axial rotation. (Columbia University Morphological Museum, No. 3246.)

Figs. 113 and 114 are good illustrations of the resulting adult conditions.

According to the statistics of Küster, compiled from those of Henry Morris and Socin, "horseshoe" kidney occurs once in 1,100 subjects.

Very frequently the fusion determines the arrest of the kidneys caudad of the normal level. In some instances rotation has occurred practically in the normal degree, the slight caudal band between the two glands, with the additional vascular connections, scarcely interfering with the typical vascularization of the main glands and the turning of the hila mesad (Fig. 113). In other instances (Fig. 114) the implantation of the ureter and vessels is much more ventral and more irregular, and rotation has evidently not been completed.

End-to-End or "Tandem" Fusion of the Renal Buds.—In this fusion-variation it must be assumed that the buds, during the period of their closest apposition, are on different vertical levels so that the caudal pole of one renal blastema touches and fuses with the cephalic pole of the opposite mass. This condition may result from a chronological variation in the renal outgrowths from the two Wolffian ducts, one bud being driven off earlier than the other of the opposite side, or the difference in level may be due to actual level-variation, one bud arising, as usual, from the Wolffian duct near its cloacal termination, while the other is derived farther cephalad from a more proximal point on the duct of its side, and hence occupies from the start a more cephalic position in reference to its fellow of the opposite side.

FIG. 114.—HUMAN ADULT. Caudal pole or "horseshoe" fusion of kidneys. Isolated preparation with arrested and atypical axial rotation. (Columbia University Morphological Museum, No. 3246.)

In any case, when this fusion-variation develops, and unless unusual circumstances intervene (Figs. 115, 116), the cephalic kidney appears to take the lead and to displace the caudal organ across the midline to its own side, interfering with its normal rotation and producing irregularities in its vascular supply.

In the following observations a number of instances of this type of fusion are recorded and figured. They present a complete and graded series, proceeding from the unmistakable condition of complete symmetrical "horseshoe" kidney, though atypical development of the same variation, with unequal renal level and disturbed rotation, to complete tandem fusion, and finally conclude with an instance of complete assimilation of the two glands into a typical gross anatomical single kidney with double ureters. The preparations are all from adult male subjects received at the anatomical laboratory of Columbia University, except the speci-

men shown in Fig. 117, which I owe to the kindness and skill of Professor Lark
Pathologist to Bellevue Hospital.

(*a*) To correctly interpret the subsequent variations it is desirable to start w
a well-developed instance of the preceding form of typical symmetrical lower p
fusion, producing a "horseshoe" junction, with nearly normal lumbar level a

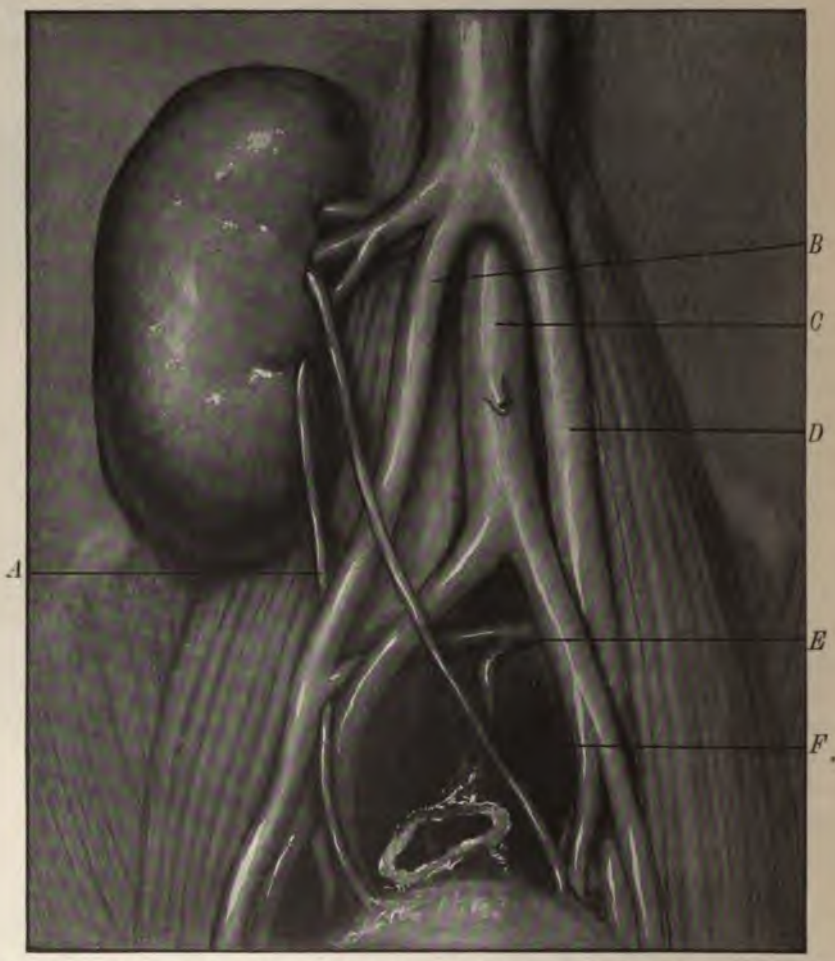

FIG. 115.—HUMAN ADULT. Crossed renal dystopia with fusion, combined with atypical developm
of systemic abdominal venous system. (Columbia University, Anatomical Laboratory Varia
Records.) *A*. Right ureter. *B*. Right postcardinal vein. *C*. Aorta. *D*. Left postcaval v
E. Iliac cross anastomosis. *F*. Left ureter.

only slight disturbance of renal rotation, causing a more ventral position of pe
and vascular connections at the hilum.

Such an instance, *in situ*, is given by the preparation shown in Fig. 118. T
kidneys in this individual have attained nearly the normal level. Both adrenals
present and typically situated. The right spermatic vein empties close to
renal-caval junction, the left at the typical point on the left renal vein. The cau
poles of the two kidneys, together with the large isthmus of renal substance unit

them ventrad of aorta and post-cava, are supplied by additional vascular trunks of considerable size. Both kidneys have rotated in the normal direction, but not quite completely. The hila with the large extrarenal pelves are placed more on the ventral surface than in normal glands.

(*b*) A typical caudal pole fusion, with arrested migration and rotation on one side, the cephalic kidney reaching the normal lumbar level, and displacing the caudal kidney up to or even across the median line.

FIG. 116. — HUMAN ADULT. Fusion-kidney of Fig. 30. Isolated. Ventral view. (Columbia University Morphological Museum, No. 3249.)

In the preparation shown in Fig. 119 the main part of the left kidney is normally constructed and has attained the usual level, with typical main blood-vessels, adrenal body and a hilum only slightly displaced toward the ventral surface. Migration and rotation have here occurred normally, but the caudal pole of the left kidney is fused with the corresponding extremity of a displaced right gland, which, by reason of the ascent of the left organ, has been pulled across the median line, with its long axis directed nearly horizontally; migration and rotation have been arrested, and the kidney arches obliquely across the large abdominal vessels at the common iliac level. The pelvis is exposed on the ventral surface of the gland, and the principal renal vessels have a nearly vertical direction (cf. course of vessels in Fig. 112). The right ureter is correspondingly short and descends near the median line, not coming into direct relation with the right spermatic vessels. The preparation illustrates exceedingly well the extent of the displacing force exerted—by reason of the fusion—on part of the dominating kidney, in this case the left one, on the subordinate organ of the other side. The left kidney, in this instance, has reached a practically normal level and, in accomplishing this ascent, has carried the atypical organ of the opposite side in the direction of its own line of advance. In comparing Figs. 118 and 119, this element of predominance on part of one or the other kidney, or arrest of migration and rotation in one, with unimpeded ascent in the other organ, in cases of caudal pole or "horseshoe" fusion, is quite apparent. The same conditions influence the adult types of the other forms of renal fusion.

(*c*) *End-to-End or "Tandem" Fusion.*—The cephalic kidney here takes the lead and incorporates the caudal gland of the opposite side into a single gross anatomical gland, with two ureters opening typically at the trigonal angles.

An excellent example of this condition is shown in Fig. 117.

The fused kidneys are placed altogether on the left side. The lumbar region on the right side contained no trace of either renal substance or adrenal body. The left adrenal is normal. In this connection it is worthy to note that, notwithstanding the genetic independence of kidney and adrenal body, and the purely topographical association of the two organs in normal adult conditions, disturbances in the metanephric development are frequently associated with similar faults in the adrenal structure.

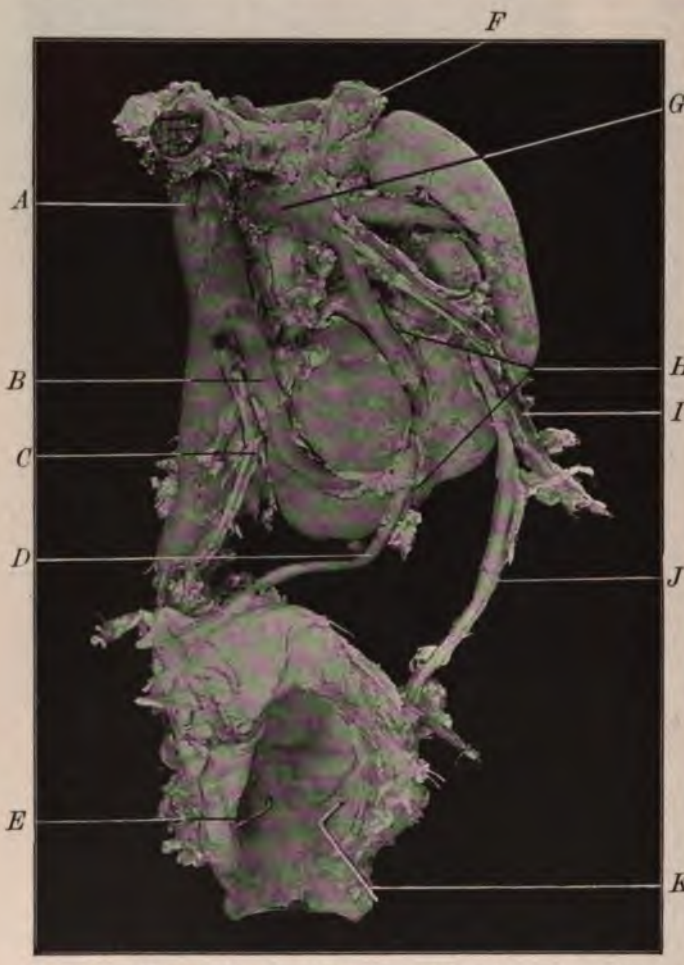

FIG. 117.—HUMAN ADULT. Cephalo-caudal end-to-end or "tandem" fusion of kidneys, with complete crossed dystopia of right kidney. (Columbia University Morphological Museum, No. 3248.) *A*. Postcava. *B*. Right renal vein. *C*. Right spermatic vein. *D*. Right ureter. *E*. Right vesical ureteric opening. *F*. Left adrenal. *G*. Left renal vein. *H*. Probable line of end-to-end fusion of kidneys. *I*. Left spermatic vein. *J*. Left ureter. *K*. Left vesical ureteric opening.

In this case the fused compound kidney is a very massive organ, measuring 7 inches in the vertical and 3.75 inches in the greatest transverse diameter. The ureteric implantations and the vascular connections are distributed over the ventral surface. The cephalic and larger part of the compound gland is evidently furnished by the left renal bud, while caudal and smaller portion represents the element contributed by the displaced primitive right kidney. The line of probable fusion is indicated by a deep furrow, containing in its cephalic portion large arterial and venous branches common to both organs, while the ureter of the primitive right kidney emerges from its distal portion, descending obliquely caudad and to the right, across the large abdominal vessels, to the right vesical ureteric opening of a well-built trigone. The fusion in this case has evidently occurred between the caudal pole of the left and the cephalic pole of the right kidney combined with a certain amount of *lateral* overlap of the two renal buds, producing in addition a *marginal* confluence and establishing a very complete union of

the two fundaments into a single gross anatomical kidney with double ureters, each duct possessing a separate vesical orifice at the lateral angles of a typical trigone. Closely analyzed, the fusion must have occurred as shown in the schematic

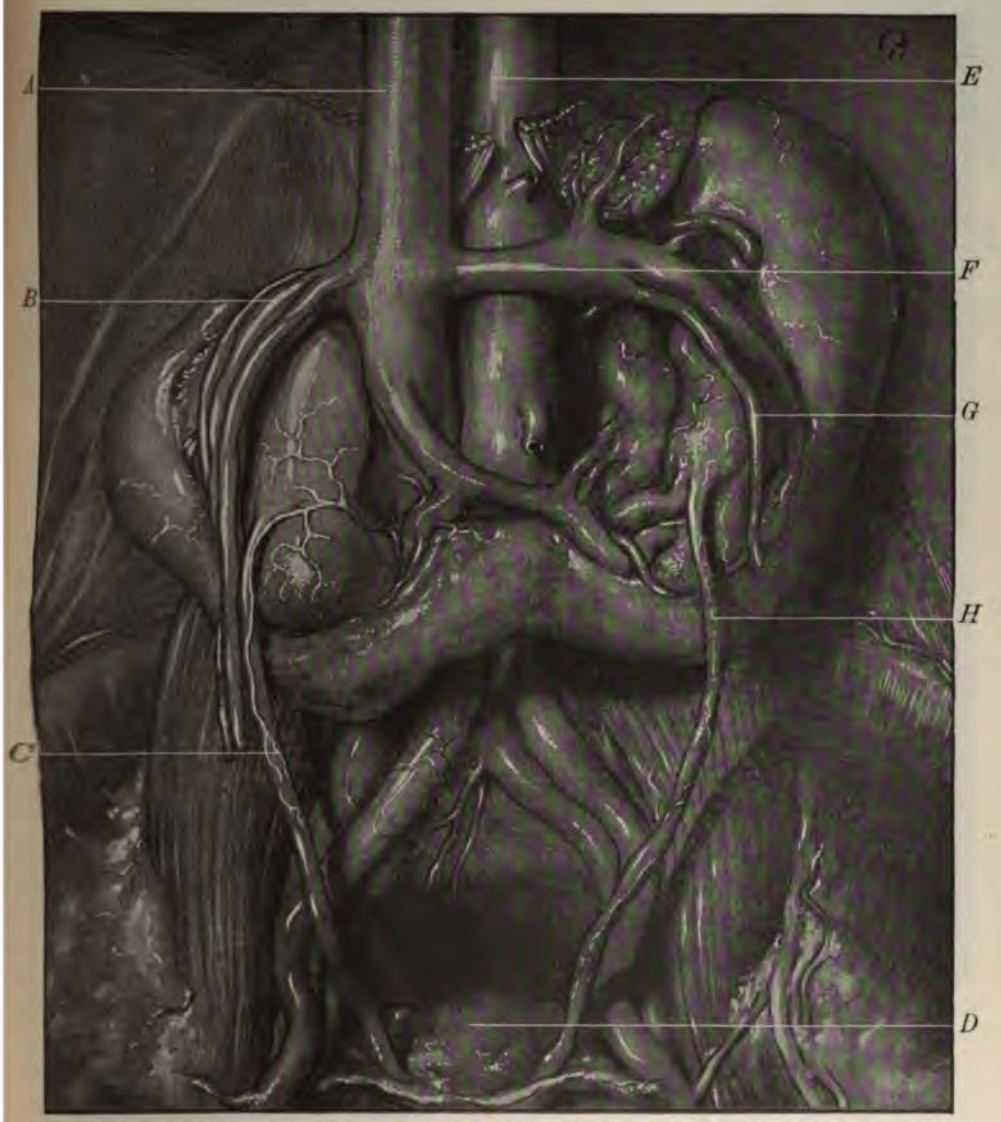

Fig. 118.—Human Adult. Caudal pole or "horseshoe" fusion of kidneys. Situs preparation. (Columbia University Morphological Museum, No. 3247.) *A*. Postcava. *B*. Right renal vein. *C*. Right ureter. *D*. Bladder. *E*. Aorta. *F*. Left renal vein. *G*. Left spermatic vein. *H*. Left ureter.

Fig. 120 involving the caudal pole of the left kidney and the cephalic pole of the displaced right kidney. The caudal part of the medial margin of the left kidney overlapped the cephalic part of the medial border of the right gland, and corresponding surface areas of the ventral aspect of the right and dorsal aspect of the

left kidney became confluent, as indicated in the shaded area of Fig. 120. Ascent and rotation have evidently proceeded normally, as far as possible under the conditions, in the case of the ascended kidney, which has carried the incorporated mass of the right gland with it completely across the median line. Typical axial rotation of the displaced right kidney has taken place, bringing the ureteric implantation to what would have been the mesal margin of the gland if normally situated on its own side. The right ureter emerges from the compound gland near the caudal limit of the common fused area (Figs. 117 and 120). The surface of the organ, therefore, situated caudad and mesad of the groove indicating the area of fusion belongs to the right kidney, and would form the lower part of the ventral surface of the same if normally situated on the right side.

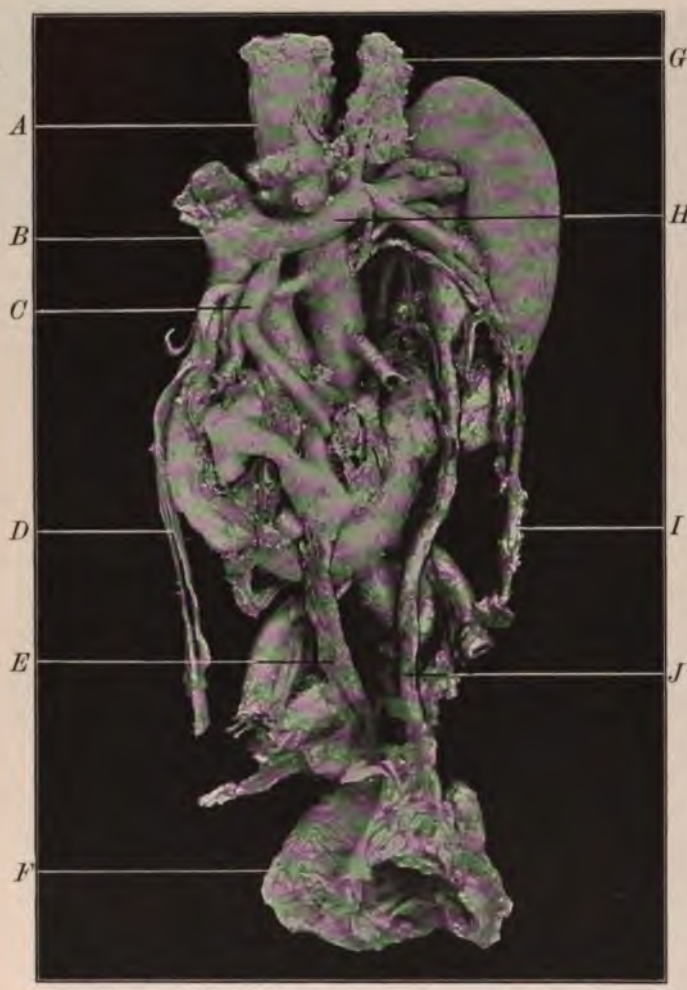

FIG. 119.—HUMAN ADULT. Caudal pole renal fusion with initial stage of crossed dystopia of right kidney. (Columbia University Morphological Museum, No. 3103.) *A*. Aorta. *B*. Postcava. *C*. Right renal vein. *D*. Right spermatic vein. *E*. Right ureter. *F*. Bladder. *G*. Left adrenal. *H*. Left renal vein. *I*. Left spermatic vein. *J*. Left ureter.

Ureters.—The cephalic (left) ureter descends obliquely over the ventral surface of the gland to the lateral margin, crossed by the left spermatic vessels, and then curves gradually to its vesical termination.

The lower (right) ureter, shorter than the left duct, emerging near the caudal end of the lateral margin, takes a sharp turn to the right across aorta and cava, descends nearly in the midline to the bladder, bends again to the right to reach its point of engagement in the bladder wall, and, reversing its direction, traverses the same to a normal ureteric orifice at the right angle of a perfectly formed trigone.

Professor McMurrich [1] has described a case of fusion variation almost identical with the one above described. He gives a tabulation with references of twenty-eight similar cases heretofore recorded in the literature of anatomically single unilateral kidneys, produced by fusion of the renal buds, and possessing two ureters opening normally into the bladder.

Another similar case is reported by E. C. Hill.[2]

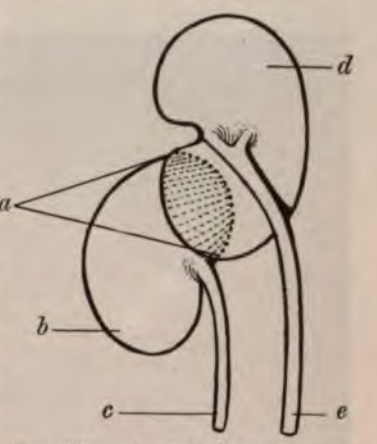

FIG. 120. — SCHEMA ILLUSTRATING TYPE OF RENAL BLASTEMA FUSION IN PRECEDING PREPARATION. *a*. Area of fusion. *b*. Right kidney. *c*. Right ureter. *d*. Left kidney. *e*. Left ureter.

We have, therefore, to deal with a perfectly well-defined embryonic variation of the kidneys which, while rare, assumes such a regular type, when it does occur, as to make the condition one of great practical importance, from the clinical standpoint. The cystoscopic examination would show a normal or practically normal trigone with right and left patent ureteric openings, both delivering urine to the bladder. This would suggest, but does not necessarily prove, the presence of two separate and distinct kidneys. With a perfectly normal ureteric bladder field the individual may possess only a single unilateral gross anatomical kidney, on one or the other side, the product of more or less complete fusion of the original bilateral renal blastemata and crossing one of them to the opposite side. Moreover, as pointed out by McMurrich and shown in one of Kruse's cases, no matter how perfect the fusion may be, the two kidneys retain their functional independence of each other, and their tubular elements do not communicate. Hence it is quite possible, as actually occurred in the case Kruse referred to, that one portion of a gross single fusion kidney corresponding to the part contributed by one of the renal buds should degenerate pathologically, while the other retains its normal parenchymatous structure. Consequently, even the differential urinary analysis by ureteric catheterization will not infallibly determine either the side of the affected organ or its gross structural independence of the remaining normal kidney tissue. The importance of these facts from the clinical standpoint becomes at once apparent if the question of nephrectomy or other extensive renal operation is under consideration. McMurrich's tabulation shows that the variation in 25 recorded cases occurs in 40 per cent on the right and in 60 per cent on the left side, and that out of 23 cases 78 per cent were males and 22 per cent females. These figures, therefore, indicate a decided preponderance on the left side and in males.

The only possible means of determining the position and course of the ureters in doubtful cases is by an X-ray picture of styleted ureteral catheters *in situ*, passed up to the ureteric pelves. Such a picture would show the

[1] J. Playfair McMurrich, "Crossed Dystopia of the Kidney, with Fusion," *Jour. Anat. and Phys.*, vol. xxxii, p. 652.

[2] Eben C. Hill, "On the Embryonic Development of a Case of Fused Kidneys," *Johns Hopkins Hosp. Bull.*, vol. xvii, No. 181, April, 1906.

course of the ureter of the crossed kidney in this type of fusion, and would form a rational basis for an exploratory operation in case the other signs and symptoms seemed to demand surgical interference with the kidney. I have used this method in a number of instances of supposed malplaced or fused kidney with satisfactory results.

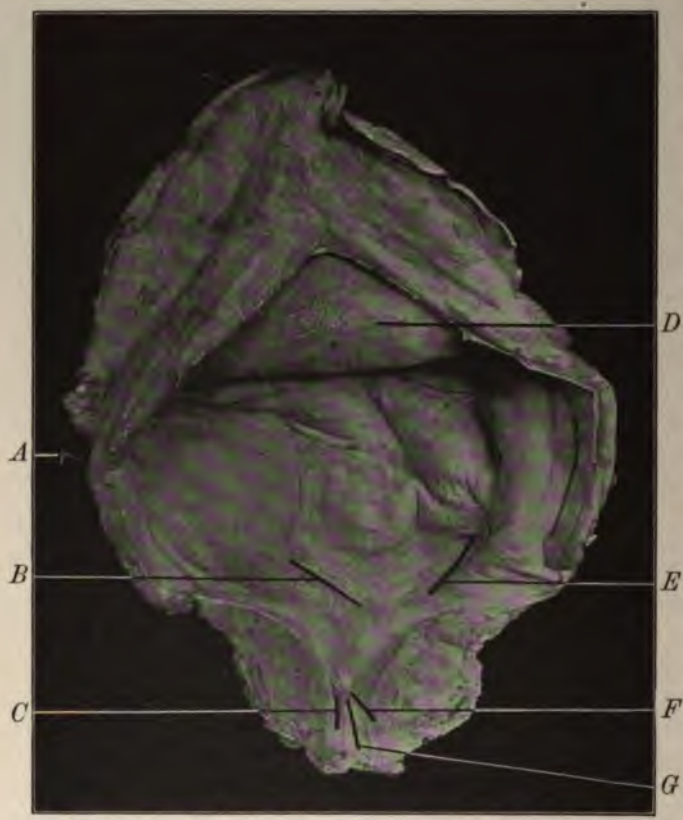

FIG. 121.—HUMAN ADULT. Bladder of Fig. 115. Ventral view. (Columbia University, Morphological Museum, No. 3250.) *A*. Right ureter. *B*. Right vesical ureteric orifice. *C*. Right ejaculatory duct. *D*. Bladder. *E*. Left vesical ureteric orifice. *F*. Left ejaculatory duct. *G*. Opening of prostatic utricle.

A unique example of crossed renal dystopia with fusion was observed by Prof. George S. Huntington:

The case, observed in the body of a male white subject fifty-six years of age, is one of unilateral single kidney of the right side with double ureter, and is shown *in situ* in Fig. 115.

Fig. 116 shows the isolated kidney with the proximal parts of the two ureters in the ventral view, while Figs. 121 and 122 show the bladder and prostate in the ventral and dorsal views.

The case is, as will appear, one of crossed renal dystopia with fusion, the cephalic pole of the right uniting with the caudal pole of the left gland, combined with an embryonal variation of the large abdominal venous trunks. The fusion is very complete, and the resulting compound organ closely imitates in shape, position and general appearance a normal, large, single right kidney with complete ureteric reduplication.

(For an analysis of the mode of production of these variations, the reader is referred to Professor Huntington's paper.)

VARIETIES AND PATHOLOGICAL RESULTS OF CONGENITAL ANOMALIES OF THE URETER

From the preceding history of the development of the kidney and ureter it can be readily understood that the ureter may be doubled either throughout

its entire length or for a greater or less distance below the kidney, the two ureters uniting in the latter case at some point above the bladder to empty as a single canal in the normal situation. When the ureter remains double throughout, one ureter, usually the *lower*, may enter the bladder at the normal trigonal angle; the other, *upper* ureter, will then enter at a lower point either in the trigonal area, or in the region of the internal sphincter, or in the prostatic urethra just lateral to the orifice of the ejaculatory duct, or in the seminal vesicle, or in the vas deferens. If the upper ureter enters the bladder at the normal trigonal angle, then the lower ureter will enter the bladder at some higher point in its floor or posterior wall. When double ureters enter the bladder by patent and ample orifices the condition is in itself of no pathological significance, but one of these ureters may become infected from the bladder, or the posterior portion of the kidney, drained by one ureter, may be the seat of infection; in this connection it is to be borne in mind that *the ureter proceeding from the upper portion of the kidney empties into the bladder at a lower point than the other.*

FIG. 122.—SAME PREPARATION. Dorsal view. *A*. Left vas deferens *B*. Left ureter. *C*. Left seminal vesicle. *D*. Bladder. *E*. Right ureter. *F*. Right seminal vesicle. *G*. Prostate.

When one or other of the ureters empties in an abnormal situation, in the urethra, the vagina, the seminal vesicle, or the vas deferens, or when one of the ureters empties at any point by an abnormally small and insufficient orifice, several pathological conditions are possible. Among these, the commonest and most important is the dilatation of the ureter, and hydronephrosis and atrophy of that portion of the kidney drained by that ureter.

When the ureter empties into the vagina there will be dribbling of urine; when the ureter empties into the prostatic urethra there may or may not be

dribbling of urine. The fact that an individual has dribbling of urine, and yet is able to empty the bladder in a normal manner, demonstrates the presence of an abnormal ureteric opening. When the ureter empties into the seminal vesicle, the ejaculatory duct, or vas deferens, these structures will be dilated, and such dilatation may produce a sac which projects forward and causes an anterior bulging of the posterior bladder wall. In certain cases when a ureter empties into the bladder by a very narrow opening, or when, as sometimes happens, such an opening is closed completely from any cause, a cystic tumor of the bladder may develop, situated between the muscular coat and the mucous membrane; such a cyst may remain small and produce no symptoms; it may grow larger, so that it presses upon the urethral orifice and causes dysuria or retention. It may grow so large as to completely fill and distend the bladder; it may even compress the other ureter, and thus cause complete hydronephrosis with atrophy of the entire kidney. Such cases are peculiarly susceptible to infection with a resulting infected hydronephrosis. In other cases the normal ureter of the other side may be compressed, resulting in interference with the function of the opposite kidney and death from uremia. In the female an obstructed ureter may cause, first, a cystic tumor of the bladder and interference with urination. Continued straining efforts may force such a dilated ureter into the urethra, and cases have been observed where the tumor projected beyond the external urethral orifice. In those cases of abnormal ureters which have produced symptoms the results have been far more disastrous in females than in males; in the former the individuals have rarely reached adult life, in the latter a number of these individuals have lived to advanced age; in some no symptoms have been produced, the condition having been observed only after death, as in the specimens collected by Professor Huntington.

In others symptoms have occurred, sometimes early, sometimes not until advanced age. When no symptoms have occurred the diagnosis will, of course, not be made during life. As might be expected from what we know of the physiology of urination, and of the relative powers of the compressor urethræ and sphincter muscles of the bladder, a ureteric opening in the prostatic urethra does not necessarily produce dribbling of urine.

DIAGNOSIS

When a patient, male or female, gives a history of dribbling of urine from infancy, and at the same time is able to empty the bladder normally, the diagnosis of an abnormal ureteric opening is, as already stated, quite positive. In the other cases in which symptoms occur, they are usually of an obstructive, sometimes also of an inflammatory, character, and are manifestly of no distinctly diagnostic value.

In cases of hydronephrosis, congenital abnormalities of the ureters are to be thought of.

When cystic tumors are observed in the trigonal region of the bladder, the diagnosis of an abnormal ureteric arrangement is probable, and might be made definitely by a careful study of the bladder with a cystoscope. For a determination of the actual conditions present, and for the origin and course of the several ureters, there is no method so useful as catheterization with styleted instruments and X-ray pictures of the individual with the catheters *in situ*.

VARIATIONS IN THE BLOOD SUPPLY OF THE KIDNEY

Variations in the blood supply of the kidney are exceedingly frequent, and possess a practical interest both from a surgical and pathological point of view. The normal blood supply of the kidney is as follows: Each kidney receives its arterial supply from a branch of the abdominal aorta—the renal artery; the vessel is of unusual size for the bulk of the organ which it supplies. Each renal artery is given off from the aorta at right angles, or nearly so, and commonly before entering the hilum of the kidney divides into four branches: two of these supply the anterior and two the posterior half of the kidney; this may be described as the common arterial arrangement.

According to Jössel, the following is a frequent type of arterial distribution: two of the four branches supply the anterior half, a third proceeds to the upper, a fourth to the lower portion of the kidney. Of the two anterior branches, one supplies the middle, the other the lower portion of the anterior half of the kidney. The superior branch supplies the upper pole, the posterior branch the lower two thirds of that portion of the kidney which lies in contact with the posterior abdominal wall. Anomalous arrangements are exceedingly common. The commonest anomaly consists in an increase in the number of arteries. Both renal arteries may arise from a common trunk given off from the anterior surface of the aorta.

The origins of multiple arteries supplying the kidney may be very varied, and the genetic causation of such variations becomes quite plain when we study the embryology of the kidney with reference to the development of its blood-vessels. Thus, multiple branches may be derived from various sources in the following order of frequency: Suprarenal; second or third lumbar; right hepatic; colica dextra; external iliac; internal and common iliac; middle sacral artery. The renal artery may even originate upon the opposite side of the body; thus Otto reported a case in which a branch of the right common iliac supplied the left kidney. Accessory arteries usually enter the kidney at the upper, sometimes at the lower pole, occasionally at other points.

When operating upon kidneys partly supplied by branches entering at unusual situations, the surgeon may encounter unexpected and serious bleeding when enucleating the organ after the vessels of the pedicle have all been severed; as stated, this will more often occur when separating the upper pole of the kidney than in other situations.

CHAPTER XII

INJURIES OF THE KIDNEY

On account of the position of the kidney in the abdomen, protected as it is by the spinal column, by thick layers of muscles, and by the thoracic wall, great force is necessary to injure it from behind; and its deep position protects it also from all but extreme degrees of violence from in front. Accordingly, injuries of the kidney are comparatively rare. In battle, injuries of the kidney, as the result of gunshot wounds, are probably fairly common, but in most of the cases associated grave injuries of the spine and of the abdominal viscera so commonly coexist that the wounds rarely come under the care of the military surgeon. In civil life, also, gunshot and stab wounds of the kidney are relatively rare injuries. Contusions and ruptures of the kidney, as the result of blunt violence without external wound, are much more common; only very rarely are injuries of the kidney by blunt violence associated with an extensive contused and lacerated wound. As might be expected, all the forms of kidney injury are far more frequent in males than in females, and they are more frequent during the second and third decades of life than earlier or later; although in large cities, like New York, where run-over accidents are so common, a considerable proportion of the ruptures of the kidney occur in children. A large proportion of all subcutaneous injuries of the kidney are associated with grave traumatisms to the other abdominal viscera, to the spine, etc. Küster collected the statistics of 306 cases of injury to the kidney without external wound. He found that the right kidney was injured more often than the left, and that 93.98 per cent of the cases were males, 6.02 per cent females. A nearly similar proportion existed among children under fifteen years of age. Of these, there were 41 cases, and 33, or 80.48 per cent, were boys; only 8 were girls. Küster explained the infrequency of kidney injuries in the female not only by their less active mode of life and less frequent exposure to external violence, but also on account of the fact that the broader pelvis and more prominent crests of the ilia in women served to protect the kidney from direct violence. Further, that women usually have a thicker layer of fat; that their corsets also probably served to protect them to some extent. The rarity of injuries of the kidney may be illustrated by the following facts: From January 1, 1890, to October 1, 1898, only 7 cases of injury to the kidney, requiring operation, entered the Roosevelt Hospital in the city of New York, a hospital

where the accident service is very large. A number of cases of injury of the kidney other than these were treated in the hospital by conservative measures, the kidney lesion not being severe enough to merit operation. Of the cases operated upon, all were males, and all but 2 were young adults; the ages ranged between twenty-eight and ten years. In 5 of the cases the injury of the kidney was caused by the patient falling some distance and striking against some hard object, which injured the loin or the lateral wall of the belly. One case was crushed between two cable cars. In the seventh case the patient, who was riding a bicycle, collided with the shaft of a wagon, which penetrated his right pleura, diaphragm, peritoneum, liver, and caused a contused and lacerated wound of the right kidney (Dr. Robert Abbe's case). Thus 6 of these cases were subcutaneous injuries. Since 1898 only 6 cases of injury of the kidney requiring operation have come under my personal observation in my service at the New York Hospital. One of these cases was a rupture of the liver, the kidney, and the lung. The case history is given under Injuries of the Liver. One was a rupture of both kidneys, ending fatally. One was a lacerated wound of the kidney, produced by a fractured twelfth rib; the broken end of the rib penetrated the substance of the kidney. A fourth was a gunshot wound of the kidney, associated with wounds of the intestine, diaphragm, and lung. One was a stab wound of the kidney, requiring suture. One was a subcutaneous laceration of the kidney, requiring nephrectomy on account of persistent bleeding. I recall an unusual case seen by me when I was house surgeon in Bellevue Hospital in the service of Dr. Frank Hartley, a stab wound in the right loin, which opened the peritoneal cavity, wounded the liver, and made a deep cut into the substance of the right kidney. The knife entered between the ninth and tenth ribs, midway between the mammary and axillary lines, and traversed the right kidney from the outer to the inner border. A small urinary fistula persisted for six months.

In 1896 Keen tabulated 155 cases of injury of the kidney. Of these, 19 were gunshot wounds, 8 were penetrating wounds of other descriptions, 118 were subcutaneous ruptures, 6 traumatic hydronephrosis, 2 partial nephrectomy for rupture, 2 ruptured ureter (pelvis). From these statistics one sees that subcutaneous ruptures of the kidney are far more common than open wounds. The injuries to the kidney substance vary much in severity, from slight contusions, attended by only a small amount of hematuria, to severe crushing injuries, in which the kidney may be pulpified or torn completely in two. The causes of rupture of the kidney are falls from a height in which the individual strikes some more or less prominent hard object, thus injuring the kidney by direct violence; or sudden and very forcible flexion of the trunk upon itself as the body strikes the ground. Other causes are blows upon the loin or the front of the abdomen, and sometimes violent muscular effort. The cases which I have seen of rupture of the kidney have been chiefly from falls or run-over accidents. As stated under Injuries of the Abdomen, in general, when the body rests against some firm surface, and a compressing

force is exercised from in front by a moving body, the kidney as well as other abdominal viscera may be injured. A number of cases of rupture of the kidney from muscular violence have been observed. Thus, Clement Lucas reported the case of an elderly man who was walking behind a wagon loaded with heavy sacks; one of these fell to the ground, and he endeavored to catch it by grasping it suddenly with both hands. He felt a severe pain in the left side of the abdomen and back, and passed blood with his urine. A second case was reported by Campbell. A young girl of fourteen bent her body forcibly to the left side while jumping over a hedge. She immediately experienced severe pain in the region of the kidney, and passed blood with her urine.

While the mechanism of ruptures of the kidney by direct violence, the result of crushing injuries or blows upon the front of the abdomen or the loin, is sufficiently clear, other cases of rupture of the kidney occur in which the violence is exerted against some distant part of the body, as when the patient falls from a height, and suddenly flexes the trunk violently, either anteriorly or to one side. Ruptures of the kidney under these conditions have been explained by the theory of hydraulic pressure, sometimes by the pressure of the ribs. Unquestionably when the lower ribs are broken the kidney may be wounded, as in the case of my own cited above. It is comprehensible that as the result of a sudden violent commotion of the body the kidney might be projected by its own inertia against the transverse processes of the vertebræ, and thus injured. The explanation of ruptures of the kidney by hydraulic pressure was made satisfactorily by Küster, who tried a number of experiments upon kidneys removed from the body and produced ruptures of various kinds, indicating that a sudden increase of hydraulic pressure was the cause of the rupture. He also found that even in the bodies of old persons after the intestine had been removed sudden violent pressure upon the lower ribs of the left side caused the ribs to bend inward and to come into contact with the kidney. In ruptures of the kidney from hydraulic pressure the lines of rupture usually radiate from the hilum toward the twelfth rib. In cases of rupture of the kidney from muscular violence, it is assumed that the muscles acting upon the lower ribs cause them to move inward, and thus compress the kidney against the spinal column.

The character of the injury to the kidney varies, as stated, in a number of ways: In the cases which I have personally seen, in two a simple transverse fissure of the kidney existed, running from the hilum to the convex border. In one the kidney was completely torn in two at about its middle. In one a contusion of the kidney existed without rupture of the capsule, but with the laceration of an artery in the kidney substance of considerable size, so that an arterial hematoma or traumatic aneurism was produced, which bled the patient nearly to death in the course of about four weeks. In another case operated upon in the Roosevelt Hospital by Dr. Frank Hartley, there was rupture of the kidney capsule, the kidney itself was extensively contused, and a very large hemorrhage had occurred into its interior, so that the organ was

greatly increased in size. Much of the disorganization of the kidney substance had probably been caused by the pressure of extravasated blood. In another case, a child of ten years, who had received a severe injury from a fall upon the right loin and suffered from marked hematuria. Exposure of the kidney two weeks after the injury for septic symptoms discovered a necrotic area in the substance of the kidney, rounded in shape, an inch in diameter, and about half an inch deep. In another case, where a man was crushed between two cable cars and developed some weeks later septic symptoms, a large tumor formed in the right loin; the kidney was found completely disintegrated at the time of the operation.

SUBCUTANEOUS INJURIES OF THE KIDNEY

The various grades of subcutaneous injury to the kidney were classified by Schede into five groups:

1. **Injury of the Fatty Capsule of the Kidney and of the Fibrous Capsule without Injury of the Kidney Substance.**—In these cases there is usually a moderate effusion of blood between the kidney and its fatty capsule; the latter is more or less extensively infiltrated with blood, and may subsequently become thickened and indurated from the formation of new connective tissue. Occasionally the hematoma results in the formation of a cyst.

2. **Contusion of the Kidney with Hemorrhage.**—Contusion of the kidney substance with hemorrhage occurs, sometimes without gross lesion, sometimes with the formation of solitary or multiple fissures in the kidney, which may be transverse or radiating, and are seldom parallel to the long axis of the organ. The ruptures do not extend into the renal pelvis. Such injuries of the kidney, although they may be accompanied by marked symptoms and hematuria, which may be profuse, rarely result fatally unless they become infected, or unless a considerable blood-vessel is torn with the formation of a traumatic aneurism.

3. **Fissures, Single or Multiple, in the Kidney Substance, for the Most Part Radiating from the Hilum, but Extending into the Renal Pelvis.**—In some of these, as in one of my own cases, the kidney may be completely torn in two. These cases are attended by profuse hemorrhage into the surrounding structures, into the fatty capsule, into the retroperitoneal tissues, or if the peritoneum in front of the kidney is also ruptured, into the abdominal cavity. The tendency of such hemorrhages is to spread downward into the mesentery of the small intestine, along the course of the spermatic vessels to the groin, into the scrotum, into the labia majora of the female, into the pelvis, and to appear superficially in the skin of the abdominal wall. These cases are very serious. The accompanying extravasation of the urine forms a dangerous complication; a considerable tumor is usually present in the loin after a few days. Hematuria may be absent, since the ureter is often plugged by a clot of blood. As a rule, unless operated upon, septic symptoms develop as the result of infection of the mixture of blood and urine with the production of a large abscess or of a

widespread necrotic inflammation of the retroperitoneal tissues. Late secondary hemorrhages may occur as the result of the necrotic process, and such may be fatal.

4. **Complete Pulpification of the Kidney.**—In these cases the kidney is extensively lacerated and torn, and considerable pieces of kidney tissue may be completely separated from the rest of the organ. The result is not dissimilar to class 3. Unless operated upon these patients die of hemorrhage or of septicemia.

5. **Injuries of the Kidney, Accompanied by Rupture of the Renal Vessels, Rupture of the Ureter, or Tearing Away the Vessels and the Renal Pelvis from the Kidney Itself.**—In these cases, unless operated upon at once, death ensues from hemorrhage or from necrotic and putrid inflammation and septicemia.

A sixth class might be added in which, in addition to the injury of the kidney, extensive multiple injuries of the other abdominal viscera or of the lung occur, and while always grave injuries, some of them are saved by prompt operation.

Symptoms, Course, and Diagnosis of Subcutaneous Injuries of the Kidney.—Since most cases of rupture of the kidney occur as the result of extreme degrees of external violence, the symptoms of more or less pronounced shock are usually present immediately after the injury, and are due, as in other cases of severe injury to the belly, to the violent mechanical disturbance of the sympathetic and abdominal plexuses of nerves rather than to any injury of the kidney itself. In other cases the symptoms of shock, even after very severe injuries of the kidney, may be entirely absent; the individual may continue to walk about, or even to work for several hours, until he begins to feel faint from internal bleeding, or until his attention is attracted to the presence of blood in his urine. Accompanying the shock, when present, nausea and vomiting are commonly observed, together with the other symptoms of shock, as already described.

Pain.—Following injuries of the kidney, severe pain is usually present at the time of the accident, although it may at first be slight, and gradually increase in intensity, as the effused blood causes tension and undue pressure upon the nerves of the kidney and its capsule, and upon the sensory nerves after their exit from the spinal column. The pain is referred to the region of the kidney, and often radiates downward along the course of the ureter into the bladder, the external genitals, and the inner surface of the thigh. External signs of injury in the neighborhood of the kidney may be present or absent; such may be abrasions, ecchymoses, the signs of a fractured rib, etc. *Extreme tenderness* over the injured kidney is present in all cases. If blood is poured out in considerable quantity in the vicinity of the kidney, a tumor mass will be formed behind the peritoneum, which may gradually increase in size for hours or days, and may extend well down to the umbilicus to one side of the median line, and be felt as a distinct tumor mass or as a mere sense of diffused resistance on palpation. Such effused blood may appear after a day or more upon the skin of the lower abdomen, in the region of the inguinal

canal, in the scrotum, in the fold of the groin. Usually, if the effusion of blood is considerable, the patient will lie with the thigh of that side flexed to relieve the tension of the muscles of the back and of the abdominal wall.

Hematuria.—The most characteristic sign of injury to the kidney is the presence of blood in the urine. It is to be borne in mind, however, that in several groups of cases hematuria may be slight or absent. If the injury of the kidney involves merely the fatty capsule and the fibrous capsule without crushing or tearing the kidney substance, no blood will appear in the urine. In very severe injuries of the kidney—namely, those in which the ureter is torn across, or in which the ureter is soon plugged by a blood clot—the quantity of blood in the urine may be small, microscopic, or even absent. In the cases where the ureter is plugged by a clot the appearance of blood may be delayed for many hours or may be intermittent. In these cases attacks of renal colic may occur, followed by the evacuation of blood casts of the ureter. If the bleeding proceeds rapidly down the ureter into the bladder, the appearances will vary in different cases. The patient may urinate blood in large quantities mixed with urine. If the bladder was empty at the time of the accident, the organ may fill up with partly coagulated blood. In these cases the patient will suffer intense pain in the region of the bladder, will have a constant desire to urinate. The contractions of the bladder wall may, however, be insufficient to force the clotted blood through the urethra, so that complete retention may occur with the formation of a tumor above the pubes by the distended bladder. In other cases the patient may be able to empty the bladder partly, and will pass urine mixed with blood. From time to time the orifice of the urethra will be plugged by a clot and the stream of urine interrupted, causing severe pain. In these cases it may be necessary to empty the bladder with an evacuator, or to suck it out with a large hand syringe and a large metal catheter having one or more unusually wide eyes. In many cases the quantity of blood entering the bladder will be small; the urine will simply be colored slightly or deeply, and will appear not bright red, but smoky or a dull brown color, indicating that the blood has been in contact with the urine for some time.

It is, of course, important to distinguish whether the blood comes from the bladder or from the kidney. This is sometimes possible. Usually in hemorrhage from the kidney the urine is evenly mixed with blood; in hemorrhage from the bladder, on the other hand, the last portion of urine passed often contains more blood than the first. The diagnosis may also be made by washing out the bladder. The bladder once evacuated and washed clean, if the hemorrhage comes from the kidney, further washings will be clear or but slightly stained with blood. If the hemorrhage comes from the bladder, repeated washings will usually appear blood-stained, since the mechanical distention of the bladder by the fluid introduced will usually be sufficient to keep up or to inaugurate fresh bleeding. The cystoscope will enable one to clear up the diagnosis in doubtful cases. If the hemorrhage comes from the bladder, the fluid medium will usually become opaque almost at once; if from

the kidney, gushes of bloody urine, in case the bleeding is still going on, may be seen proceeding from the orifice of one or other of the ureters; or a clot may be seen adhering to the orifice of one ureter. If the bleeding has permanently or temporarily ceased, the cystoscopic field may be so clear as to enable us to eliminate the bladder as the source of blood. The passage of cylindrical blood casts of the ureter *per urethram*, while characteristic of renal hemorrhage is inconstant.

When the quantity of the blood that is found in the urine is very large, it is seldom possible to make a differential diagnosis as to its source from microscopic examination. Injuries of the kidney are usually followed by a traumatic nephritis, and after a hemorrhage from the kidney has ceased, examination of the urine will often detect hyaline casts, sometimes containing granules, sometimes red blood cells and renal epithelium. Such a traumatic nephritis is associated with an albuminuria, and the quantity of albumin is greater than can be accounted for by the small quantity of blood present. Polyuria is frequently present in these cases. Traumatic nephritis is sometimes associated with edema of the extremities, and even with generalized edema. This is, however, a relatively rare occurrence. In the very extensive ruptures of the kidney the symptoms of internal hemorrhage may be present of any possible grade. In the worst cases the symptoms of progressive anemia may increase from hour to hour, and unless operated upon the patient may bleed to death in a very short time. In such cases the local signs of the formation of a tumor mass in the region of the kidney will be marked. If the peritoneum has been ruptured, in addition to the signs and symptoms of hemorrhage, there will be evidences of an accumulation of blood in the peritoneal cavity. These signs have been described in another section under the Diagnosis of Injuries and Diseases of the Abdomen. The hemorrhage following contusion of the kidney may be intermittent, notably if a considerable artery is torn without rupture of the kidney capsule. This is well illustrated by the following case observed in the Roosevelt Hospital in 1894: The patient was a boy, aged sixteen years. A week before coming to the hospital he had fallen, while running, against a wooden beam, which had injured his right loin. He did not suffer from shock, and walked a considerable distance to his home, where he went to bed, and remained during the following week. He had observed that his urine was red after the accident. Upon admission to the hospital his temperature was 99° F., his pulse 100. He was passing a diminished quantity of urine, 14 ounces in twenty-four hours. This was slightly brownish in color, and contained a moderate amount of blood. There was pain in the region of the right kidney, moderate tenderness, and muscular rigidity. He left the hospital at the end of three days feeling better, and desiring no further treatment. Twelve days later he returned. On the preceding day he had passed a large amount of blood *per urethram*. There was no tumor in the loin nor noticeable tenderness. At this time his pulse had become rapid, 110. He had a slight amount of fever. His urine contained some blood.

Upon the two following days he passed a considerable quantity of blood with the urine. The bleeding continued during the next five days with the symptoms of progressive anemia. Three weeks after the accident his right kidney was removed. The kidney was slightly enlarged. There was a bulging tumor at the center of its convex border. Upon incising the kidney a considerable cavity was found in the kidney substance, an inch and a half in diameter. This cavity contained a globular clot of bright blood, inclosing firm clots and masses of fibrin, partly decolorized. In the wall of the cavity the open mouth of an artery of considerable size plugged with a soft and recent thrombus was discovered. The capsule of the kidney was not ruptured.

The course of a case in which the kidney was torn completely in two will serve to illustrate another type. The patient was a man, aged twenty-two years, who was admitted to the Roosevelt Hospital, February 7, 1898. On the day of admission he had fallen, while walking along a beam, a distance of six feet, and had struck with his left loin on the end of a post. He suffered sudden, sharp pain in the loin, and exhibited symptoms of shock. Upon admission to the hospital, examination showed a large, robust man. He was very pale. His pulse was soft and slow, 72 beats per minute. Temperature normal. There was marked tenderness in the left loin over the kidney and abdominal rigidity in front. There was dullness on percussion in the left loin, extending forward as far as the vertical plane passing through the anterior superior spine of the ilium. Half a pint of nearly pure blood was removed from the bladder by a catheter. The urine for the next two days was continuously bloody. The third day after the accident the blood had nearly disappeared from the urine. The patient was profoundly anemic. He developed a septic temperature, 104.5° F., his pulse was 115. There was pain, rigidity, and marked bulging of the abdominal wall in the left hypochondriac region and posteriorly. On this day I removed his kidney through a cut parallel with the border of the ribs. Upon approaching the kidney a large retroperitoneal hematoma was opened, containing nearly a quart of fluid blood. At the bottom of this cavity the kidney was found torn transversely completely across into two equal portions. The torn edges and the adjoining kidney substance were extensively pulpified. The kidney was removed. Blood entirely disappeared from the urine after the operation, and thirty-four ounces of urine were passed during the first twenty-four hours. The patient made an uninterrupted recovery.

The following case history illustrates that a serious subcutaneous rupture of the kidney may be attended by trifling symptoms at first. In this case the kidney and the pelvis of the ureter were torn by a fall against a hard object.

The persistent hemorrhage would, no doubt, have caused the patient's death had not the kidney been removed.

A. C., male, aged fifty-nine years, native of France, a cook.

On July 6, 1907, at about 7 A.M., he was lowering a small cart down some stone steps. He stumbled and fell a distance of only two or three steps, striking on his

left side against the edge of the lowest step. He experienced a sharp pain in his side, but arose, went about his work, and did not consider himself seriously hurt. He had some pain, like a stitch, in his left side, some difficulty in taking a deep breath, and that was all. Nearly eight hours later he had a strong desire to urinate; he went to the closet, urination was difficult and painful, and he observed that his urine was deeply stained with blood.

He sent for and was brought to the New York Hospital in an ambulance.

On Admission.—Patient is a large stout man. Skin and mucous membranes normal in appearance. There is a fracture of the tenth rib on the left side about three inches from its anterior extremity.

Abdomen.—There is tenderness beneath the free border of the ribs in the left hypochondrium, and tenderness in the lumbar region of the same side. Temperature, 98.2° F.; pulse, 76; respirations, 20. The patient urinated liquid of a dark wine-color. The patient entered the service of Dr. F. W. Murray. He was kept quiet in bed. His urine continued bloody. On the eleventh day of July, four days after admission, his hemoglobin was 60 per cent, on the seventh day after admission it was 58 per cent, on the ninth day after admission it was 52 per cent. On that day the left kidney was exposed by Dr. Murray through a five-inch incision parallel with the twelfth rib. The fatty capsule of the kidney was found infiltrated with blood. The kidney itself appeared swollen in its lower half. The capsula propria was incised and the incision gave exit to blood clots. The hematoma was cleaned out and the wound in the capsule drained by a strand of gauze. Suture of the external wound. The patient then fell under my care. From July 15th until July 19th the patient continued to pass bloody urine. He suffered from painful and difficult urination and much vesical tenesmus. On this day I again exposed the kidney through the same incision. A jagged rent was found in the posterior surface of the kidney near its lower pole. The tear extended from a point an inch and a half distant from the hilum inward and opened the pelvis of the ureter for the distance of an inch. The borders of the rent in the kidney substance were friable and appeared to be necrotic. The kidney was removed. The patient made a good and satisfactory convalescence. In addition to the lesions described, the kidney contained several small areas of contused tissue resembling infarcts. These areas were necrotic.

Operative Indications.—Only the more severe subcutaneous injuries of the kidney demand immediate operation, the indications being the rapid development of the general symptoms of hemorrhage—namely, acute progressive anemia or the formation of a tumor mass surrounding the kidney combined with such symptoms or alarming hemorrhage through the ureters and bladder. A good many of the cases where the kidney substance is contused but the capsule is not ruptured, and where the contusion does not extend into the renal pelvis, are attended by only a moderate amount of hematuria, which gradually subsides, and is followed by a return to health. In the cases where a considerable artery is torn, with the formation of an arterial hematoma in the kidney, repeated hemorrhages of a severe grade constitute a positive indication for operation. In those cases where the capsule of the organ is torn and where blood and

urine are extravasated into the surrounding tissues in the absence of indications for immediate operation on account of hemorrhage there will develop in the course of days or weeks septic symptoms which are accompanied by characteristic signs: The formation of a boggy, tender tumor in the loin, profound prostration, etc., and in these the operative indications will become quite plain. In the cases attended by severe degrees of shock, or accompanied by injury of other important organs, the operative indications must be diagnosticated upon general principles. The surgeon will seek to differentiate the symptoms of shock and of hemorrhage, and these have been sufficiently dwelt upon under the diagnosis of Injuries and Diseases of the Abdomen. If the symptoms of shock are gradually recovered from in the course of hours, the surgeon may safely wait, unless the amount of bleeding from the kidney is alarming or unless the symptoms of internal hemorrhage are manifest. Those ruptures of the kidney, accompanied by laceration of the peritoneum and extravasation of blood into the peritoneal cavity, will be attended by the symptoms of peritoneal irritation, and if not operated upon by peritonitis. The general signs and symptoms of severe abdominal injury, the history of the accident, the presence of severe abdominal pain, rigidity of the abdominal wall, will furnish indications for immediate operation, as in other injuries of the abdomen.

OPEN WOUNDS OF THE KIDNEY

Incised and Stab Wounds of the Kidney

Incised and stab wounds of the kidney are rare injuries as compared with subcutaneous lacerations. The recorded cases in modern publications appear to number less than one hundred. In the American Civil War no case of incised or punctured wound was recorded (Otis). The wounds have been produced by cuts and thrusts with knives, daggers, bayonets, rapiers, scythes, scissors, rarely by impalement on sharp stakes; in one case (Murphy) a man fell upon the handle of a hayfork, which entered the rectum, penetrated the colon, and crushed the upper pole of the left kidney. In Abbe's case the pole of a wagon entered the thorax, wounding the pleura, liver, and kidney. The wounds have varied in size from narrow punctures to incisions wide enough to permit the prolapse of kidney. Wounds made in front have usually been complicated by injury of other abdominal viscera. Wounds made from behind usually involve the pleura, sometimes the liver.

Signs, Symptoms, and Diagnosis of Incised and Stab Wounds of the Kidney.—From the size, situation, and depth of a wound, injury of the kidney may be recognizable on inspection and palpation. In other cases the injury may be inferred more or less certainly from concomitant signs and symptoms, or from the character and length of the instrument which produced it, the degree of violence, and the direction of its application.

The free escape of urine from the wound indicates an injury of the kidney involving the pelvis or a wound of the ureter; hematuria will usually coexist. In wounds of the cortical substance merely, both of these signs will regularly be absent, or a small amount of transient hematuria alone may occur. Urine escaping from the external wound, either alone or mixed with blood, may be recognized by the urinous or ammoniacal odor soon developed in the saturated dressings. If the size, situation, and shape of the wound in the abdominal wall be unfavorable for its escape, the urine will be extravasated into the perirenal tissues or into the peritoneal cavity, and a septic inflammation or a peritonitis will follow, as the case may be, giving rise to characteristic symptoms and signs—i. e., localized pain and tenderness, a boggy swelling in the loin, fever, prostration, etc., or evidences of peritoneal irritation if the extravasation has taken place into the peritoneal sac.

Hematuria.—As stated, when the wound enters the pelvis, the appearance of blood in the urine may be almost immediate, and this sign, together with the situation of the wound, is almost certain proof of a wound of the kidney; a wound of the ureter or its pelvis is the sole alternative. Hematuria may be absent if the cortex only is wounded, or if the ureter or pelvis is completely divided, or if the ureter is plugged by a clot, or if a large renal vessel be divided, so that much blood escapes into the peritoneum, into the perirenal tissues, or externally. In some cases blood will accumulate in the bladder, giving rise to vesical tenesmus and frequency, sometimes to retention, as described under Subcutaneous Injuries of the Kidney. Hematuria may be delayed for hours, even for days, and may be small in amount, or so severe as to cause death from loss of blood.

The symptoms of shock and the general symptoms of hemorrhage may be present or absent, and possess no distinctive diagnostic importance.

Pain.—Incised wounds of the kidney are not necessarily very painful. The external wound causes pain similar to that of any wound, but the wound of the kidney itself is not accompanied by severe pain unless the tension of the capsule of the organ is increased by blood extravasated beneath it, or unless the pelvis or ureter is plugged by a clot; there will then occur severe pain of a spasmodic character, a typical renal colic, often associated with nausea and vomiting. The pain radiates downward along the ureter into the groin and testis; the latter is retracted. The development of wound infection, of urinary infiltration, or of peritonitis will be accompanied by pain of a character described elsewhere.

To sum up the early diagnostic features of wounds of the kidney I quote from Henry Morris, *loc. cit.*:

(1) That a wound of the renal region followed by the escape of urine through the wound is conclusive of injury of the kidney; (2) that such a wound quickly followed by the discharge *per urethram* of urine heavily mixed with blood is almost conclusive, if not quite so; (3) that such a wound followed by retention of urine, or lumbar or abdominal pain and dysuria, even without hematuria, is highly sug-

gestive of a superficial wound and blockage of the ureter; (4) that hematuria followed by traumatic peritonitis is strong evidence of an injured kidney.

The following case of stab wound of the kidney was recently treated by me in the New York Hospital (see Fig. 123):

William C., aged thirty-nine, native of the United States, foreman of a gang of workmen employed in the construction of a building close by the hospital. At 3 P.M. on September 4, 1906, he got into an altercation with an Italian peddler who was obstructing the sidewalk; as the foreman turned to walk away the peddler stabbed him in the back with a knife having a blade four inches long, sharpened on both edges, and three quarters of an inch wide. The wounded man felt weak and sick; he walked into the hospital, two hundred feet away. He had no pain. Upon admission, examination showed him to be a large, muscular, well-nourished man. He looked pale, his pulse was rather rapid; sole complaint, a feeling of weakness. Upon inspecting the seat of injury, there was a linear wound—three fourths of an inch long running obliquely downward and forward—situated four inches from the middle line of the back upon the right side, between the eleventh and twelfth ribs (see Fig. 123). The wound scarcely bled. There were no signs indicating injury of the pleura or lung. After being in the hospital half an hour he urinated three ounces of bright blood.

FIG. 123.—STAB WOUND OF THE KIDNEY.
(New York Hospital, author's case.)

A diagnosis was made of stab wound of the right kidney. The patient was kept under observation until the following morning, when the continued presence of large quantities of blood in the urine caused me to expose the kidney through an incision below and parallel to the last rib. A portion of this rib was removed to permit easier access to the kidney. There was a hematoma of moderate size in the perirenal fat. The kidney was freed and delivered into the external wound. A horizontal linear wound three quarters of an inch long was then seen on the posterior surface of the organ near the outer border; this wound bled freely as

the result of the manipulations. A blunt instrument passed freely through the kidney into the ureteric pelvis. The wound in the kidney was sutured and the bleeding stopped by a single deep mattress stitch of catgut. The operation wound was then closed in layers, except for the posterior angle, where a gauze wick was introduced down to the kidney. The stab wound in the external soft parts was let alone. After the operation the hematuria was at once reduced to a minimum and soon ceased. Primary union was obtained in the sutured portion of the wound and no apparent leakage of urine took place. The patient had a rapid and normal convalescence and was able to return to his work in a few weeks.

Prolapse of the Kidney through a Wound.—Wounds in the lumbar region below the ribs, if of sufficient size, have been followed in a number of instances by total or partial prolapse of the kidney; the kidney may or may not be injured. The prolapse has occurred at once from increased intra-abdominal tension, produced by coughing or vomiting, or at a later period. Constriction of the pedicle of the kidney by the wound margins, usually sufficient only to occlude the renal vein, causes swelling and congestion of the organ, profuse hemorrhage from an existent wound of the kidney itself, or, in other cases, hematuria. If the kidney remains unreduced, thrombosis of its vessels occurs, followed by gangrene. The diagnosis is to be made on inspection if the prolapse is complete; if partial only, digital exploration would at once reveal the characteristic shape of the kidney.

The Prognosis of Incised Wounds of the Kidney.—The prognosis of incised wounds of the kidney varies within wide limits, according to the presence or absence of complicating injuries. Simple incised wounds of kidney cortex heal well if not infected, usually *per primam.* Injury of the renal artery or vein is attended by such severe bleeding that speedy death results unless immediate surgical aid is at hand. Death from sepsis due to urinary infiltration, or from peritonitis, is common in untreated cases; a wound opening the renal pelvis or the peritoneum has probably been present in many of these. In some cases death has been due to nephritis; to uremia from suppression of urine; in a few cystitis has been recorded as the cause of death.

Among 8 cases tabulated by Keen, 6 recovered and 2 died—1 from uremia, 1 from sepsis and abscess of the liver. In 12 cases reported by Edler death occurred in 5, and was due to primary bleeding twice, twice to secondary bleeding, in 1 death followed nephrectomy. Among Keen's cases, 4 were treated by nephrectomy; all recovered. Küster collected 43 cases with 10 deaths; among these cases many had severe complications. Of 31 uncomplicated cases, but 4 died. The prognosis is profoundly modified by prompt and efficient treatment and, on the other hand, by neglect.

Gunshot Wounds of the Kidney

Bullet wounds of the kidney uncomplicated by other serious injuries are rare; the renal vessels, the pleura, lung, diaphragm, liver, stomach, spine, etc.,

are very commonly injured as well; such wounds are so rapidly fatal that, when received in battle, they rarely come under treatment. The explosive effect of the high-powered rifle bullet is well marked on the kidney; the organ is often found torn in all directions or reduced to a pulp; even wounds from pistol bullets show a considerable degree of laceration of kidney tissue. Simple perforations from high-powered rifle bullets are only seen at extreme ranges. Among the cases of pistol-shot wounds, if the bullet merely grooves the cortex, or if the injury is confined to the cortex, the prognosis is much better than though the pelvis and the renal vessels are injured. Small pistol bullets fired at low velocities may perforate the kidney without producing very serious damage, and a number of such cases have, undoubtedly, recovered without operative interference.

In the simpler forms of gunshot wound of the kidney hemorrhage is not usually very profuse. The dangers are shock from complicating injuries; hemorrhage from injuries of the renal vessels, sepsis from wound infection, caused by unclean manipulations of the wound, from extravasation of urine, from the entrance of foreign bodies—i. e., portions of clothing along with the bullet, from an ascending infection caused by imperfect asepsis in catheterization, the production of cystitis and infection of one or both kidneys.

The number of recorded cases of gunshot wounds of the kidney in which no other important structure has been wounded is not very large. In warfare the frequency of gunshot wounds of the kidney was estimated by Edler, and independently by Küster, at 0.12 per cent of all wounds. Statistics compiled from a number of sources indicate that penetrating gunshot wounds of the abdomen involve the kidney in about 7.3 per cent of the cases. The following statistics give some idea of the mortality in gunshot wounds of the kidney.

In the American Civil War 85 such wounds were followed by 26 recoveries and 59 deaths—a mortality of 69.41 per cent. In the Franco-Prussian War, among 15 gunshot wounds of the kidney there were 8 deaths and 7 recoveries —a mortality of 53.33 (Küster). These results represent wounds from large soft-lead bullets in preantiseptic days. The prognosis of wounds of the kidney occurring in civil life, such being, for the most part, pistol-shot wounds, is notably better; thus, Küster collected 29 such cases, with 21 recoveries and 8 deaths —a mortality of 28.41 per cent. The prognosis is, as already stated, profoundly modified by associated injuries.

Experiences gained in recent wars seem to show that uncomplicated wounds of the kidney produced by small-caliber rifle bullets at long ranges may be simple perforations, and so long as they do not open the pelvis or injure the renal vessels may heal without operative interference and without trouble. It is to be borne in mind that though no serious bleeding may occur immediately, the separation of the eschar produced by the bullet, at the end of five to ten days, may be followed by serious or even fatal secondary hemorrhage, evidenced by profuse hematuria or by the formation of a perirenal hematoma, or by bleeding from the external wound. In some cases the colon has been

wounded and the blood has escaped *per rectum*. Infection and perirenal suppuration are quite prone to occur; a certain number of instances of this kind have been observed as the result of the passage of a foreign body, usually a piece of cloth, into the wound, and, in a few instances, such fragments of cloth have eventually been passed *per urethram* after months of perirenal suppuration, pyelitis, and cystitis.

Diagnosis of Gunshot Wounds Involving the Kidney.—The diagnosis of gunshot wounds involving the kidney may sometimes be made from the objective signs of injury of the kidney, as already described; in other cases the symptoms will be those of shock and intra-abdominal bleeding, as in stab and incised wounds. The cardinal signs are *hematuria* and the *escape of urine* from the external wound. Owing to the narrow wound of entrance, this latter sign is much less common in gunshot injuries. If the ureter is plugged by a clot, severe renal colic may be present.

In gunshot wounds involving the abdominal viscera, operated upon for the control of bleeding or for the repair of wounds of the hollow viscera, it will be rare that the surgeon can diagnosticate injury of the kidney before opening the abdomen, unless hematuria or kidney colic have existed. The anatomical site of the wound and the direction of the wound canal may aid in the diagnosis, notably when made by a small-calibered jacketed rifle bullet, since, as stated elsewhere, these bullets pursue a straight course through the body. The track of a soft-lead pistol bullet through the tissues, on the other hand, can only be surmised, deflection being caused by bones, tendons, and fascial planes in a large proportion of cases. The location of a lodged bullet may be determined by means of stereoscopic radiographs or with one or other form of localizer; such measures might possibly locate a bullet lodged in the kidney, but would scarcely be of much diagnostic aid in ordinary cases.

CHAPTER XIII

MOVABLE KIDNEY

UNDER the Diagnosis of Diseases and Tumors of the Abdomen the methods of examining the kidney and the physical signs of movable kidney have been dwelt upon at some length. We shall here consider the symptoms of the condition, together with some other diagnostic data.

It is to be borne in mind that movable kidney bears no resemblance to congenitally misplaced kidney, the latter being usually firmly fixed. We have already referred to the normal respiratory mobility of the kidney—more marked in women than in men, and sometimes appreciable on palpation in slender subjects; this mobility is rarely greater than an inch.

Occurrence.—Movable kidney occurs in women in 85 per cent of the cases, in men rarely. The fossa in which the kidney lies is shallower and wider at its lower part in women than in men. The frequency of movable kidney among women varies greatly, according to the statistics of different observers —i. e., from 3 to 46 per cent. Edebohls found 90 movable kidneys among 500 women. Glenard, who found 537 cases in eight years, states that movable kidney occurs 22 times among every 100 women. The majority of cases are observed between the twentieth and fortieth years of life. The condition has been observed in infants and among the aged. In 30 cases requiring operation I observed but 2 males, and in 1 of these the kidney became movable as the direct result of trauma. The right kidney is movable 15 times as often as the left. Among women repeated pregnancies with the resulting flabby condition of the abdominal walls are often followed by movable kidney, sometimes alone, sometimes as a part of a general enteroptosis. Another large contingent is seen among slender, rather poorly nourished females of lax fiber, with long thoracic cavities, who have never borne children. The causative relation between tight lacing and movable kidney appears to me almost doubtful; since, among races who wear no constricting clothing about the waist, movable kidney is quite common (Samoa——Becher and Lennhoff; Egypt—Trekaki). Violent muscular effort, sudden generalized violence to the entire body, as in falls, railroad accidents, etc., and blunt violence, such that if more severe would have produced rupture of the kidney, are direct causes in a moderate number of cases; rapid emaciation is sometimes observed as a cause.

The Symptoms Produced by Movable Kidney.—The symptoms produced by movable kidney are very varied. Most important is it to bear in mind that in

a large proportion of cases no symptoms whatever occur. Thus, G. Brewer found, in 200 subjects examined, the upper pole of the kidney below the free border of the ribs 11 times, and yet in only 1 of these were symptoms produced referable to the kidney. The practical deduction to be drawn is that the surgeon who operates upon every movable kidney he finds, does a great many unnecessary operations.

In a certain proportion of cases, however, marked symptoms occur; they may be divided into: (1) Pain. (2) Digestive disturbances. (3) Changes in the urine and disturbances of the urinary apparatus. (4) Pressure symptoms on the duodenum and biliary passages—such as dilatation of the stomach, jaundice, appendicitis from congestion of the appendix caused by compression of the superior mesenteric vein between the head of the pancreas and the spinal vertebræ by the displaced kidney (Edebohls). (5) Nervous symptoms—neurasthenia and hysteria.

1. *Pain.*—The severity of the pain produced by movable kidney varies much in different cases. In a certain rather small number there occur attacks of pain, supposed to be due to kinking or torsion of the entire kidney pedicle, or of the ureter alone. This condition was described by Dittel in 1864 under the name "incarceration of the kidney." The attacks are sometimes known as "renal paroxysms" or as "Dittel's crises." They occur suddenly; the patient is seized with violent abdominal pain, which increases to unbearable severity; nausea and vomiting usually follow; the patient may fall into a condition of collapse, with a small thready pulse, coldness of the extremities, and clammy sweating; it is stated that such an attack may even be fatal. There may be a chill and high fever. Upon physical examination the kidney will be found exquisitely tender, and usually palpably enlarged. After enduring hours or days, the attack subsides as rapidly as it began; the patient has a sudden sense of complete relief. If the condition has been one simply of a kinking of the ureter, subsidence of the pain will be followed by a transient polyuria—the condition has been one of acute hydronephrosis. More commonly the attack is caused by torsion of all the structures of the pedicle, causing intense venous congestion of the kidney and greatly increased intracapsular tension. In these latter the attack is apt to last longer, and reduction is not followed by so rapid a return to normal as in the former group of cases.

In the somewhat rare cases in which spontaneous reduction does not soon occur, the attempt may be made to rotate the kidney bimanually into its normal position; this effort has been successful in a few cases. Prolonged rest in bed is a very valuable and usually temporarily successful mode of treatment; elevation of the foot of the bed, and even a partial "Trendelenburg posture" may also be tried. In other cases exposure of the kidney and its fixation in the loin by sutures is a certainly curative procedure. In the large majority of cases of movable kidney no such severe attacks occur; the patient may suffer from moderately severe attacks of pain in the loin, in the sacral region,

from neuralgic pains radiating into the lower extremities, from a sense of dragging and weight in the abdomen and back, made worse by the erect posture and by exercise. Such sensations may be more or less constant while the patient is up and about, but usually subside after lying in bed for some hours. The pain is worse during menstruation, and this condition often appears to be the determining factor in the production of an unusually severe attack.

2. *Digestive Disturbances.*—Accompanying the attacks of pain, or independently, there may occur nausea and vomiting and a burning pain in the epigastrium, often persisting for days. Obstinate constipation is common, occasionally diarrhea.

3. *Changes in the Urine and Disturbances of the Urinary Apparatus.*—The urine remains normal in most cases of movable kidney; transient albuminuria and even the presence of a small amount of blood in the urine during or after an attack undoubtedly occur in a few cases. Disturbances of urination are quite common—frequency, straining, and painful urination. Polyuria is often observed at the end of an attack, and has rarely been a prominent symptom at other times. In a very few cases during a renal paroxysm, oliguria, even anuria, and the symptoms of uremia, have been observed. Repeated attacks of this kind may lead to gradual dilatation of the renal pelvis and chronic hydronephrosis. (See Hydronephrosis.)

4. *Pressure Symptoms.*—That movable kidney may, by traction, cause partial constriction of the duodenum and, rarely, gastric dilatation, and even obstruction, of the common bile duct, has been proven in a few instances. The mechanism whereby the congestion of the vermiform appendix and a predisposition to appendicitis may occur has been mentioned (Edebohls).

5. *Nervous Symptoms—Neurasthenia and Hysteria.*—One of the most common, though not invariable, accompaniments of those cases of movable kidney presenting symptoms—both in men and women—is a condition of neurasthenia, more or less profound, often associated with hysteria. In a certain proportion of cases fixation of the kidney by operation causes a disappearance or amelioration of the nervous symptoms. Such is not always the case; some of these unfortunates remain as neurasthenic as before. If a condition of general enteroptosis exists, or if the patient has been neurasthenic before symptoms referable to the kidney appeared, the surgeon should be very cautious about promising an improvement in the nervous condition from fixation of the kidney. These patients are, as stated elsewhere, apt to acquire the surgical-operation habit and go from one operator to another, having the kidneys fixed, the appendix, the ovaries, even the uterus, removed; when all that is accomplished they are no better, and may subsequently have several more operations, for postoperative adhesions, for ventral herniæ, etc.

Differential Diagnosis of Movable Kidney.—The differential diagnosis of movable kidney rarely presents serious difficulties. In the presence of characteristic symptoms, the finding in the abdomen of a movable tumor having the

size, shape, and consistence of a kidney is enough to establish the diag
The manner in which the kidney slips upward beneath the ribs from be
the examining hands is striking. Other movable tumors of the belly are
sionally mistaken for kidneys. The diagnosis is based upon the data
under the Diagnosis of Tumors of the Abdomen.

CHAPTER XIV

HYDRONEPHROSIS

As the result of partial or intermittent closure of the ureter, or of such closure which gradually becomes complete, the ureteric pelvis, the calices, and even the *capsula propria* and the kidney itself, may become dilated by the back pressure of urine into a sac of varying size and shape, containing urine, more or less modified in character. As the sac increases in size the pyramids and, finally, the kidney cortex undergo a more or less complete atrophy, and may totally disappear. The condition is known as *hydronephrosis* (Rayer). Guyon and Albarran gave it the name *uronephrosis*; when such a sac containing urine became infected, so that a more or less septic urine containing pus formed its contents, they called it *uropyonephrosis*. In America this condition is usually called *infected hydronephrosis*; when the process is purely a suppurative one, it is spoken of as *pyonephrosis*.

When one ureter is suddenly, completely, and permanently obstructed but little distention of the pelvis and calices occurs; on the contrary, the kidney undergoes a rather rapid atrophy. In the production of hydronephrosis the site of obstruction may be anywhere from the preputial orifice to the kidney; but when below the ureter both kidneys are affected alike, and, as will be pointed out, the hydronephrosis produced does not, *as such*, possess the same surgical interest as when the ureter is the seat of obstruction and the disturbance limited to one kidney.

Etiology.—The causes of ureteric obstruction with dilatation and the production of hydronephrosis are very varied; they may be divided into congenital and acquired obstructions.

Congenital Obstructions Causing Hydronephrosis.—In the congenital forms the ureter itself is the usual seat of the anomaly—such may be an impervious ureter; congenital stricture of the ureter at any point; a narrowed vesical orifice of the ureter (seen in exstrophy of the bladder); a ureter emptying in an abnormal situation and too narrow to perform its function or with a narrowed orifice; an abnormal origin from the pelvis of the kidney producing angulation or valve formation in the ureter; twists in the ureter producing occlusion or obliteration of its canal; angulation of a ureter arising from a congenitally misplaced kidney. *Extrinsic congenital causes* are pressure upon the ureter by an anomalous renal artery or vein, or by an additional ureter, or

by a congenital cystic tumor arising from Müller's duct (Reliquet). In a considerable proportion of the congenital cases both kidneys are involved; this is always true when the obstruction is at the prostate, or in the urethra, or due to phimosis with a very narrow orifice; among this latter group of cases a congenital defect of the urethra (imperforate urethra) appears to be a very common cause. Henry Morris describes a case due to torsion of the penis.

A good many infants, subjects of congenital hydronephrosis, are born with marked dilatation of the kidney; many are not viable on account of this or associated congenital defects. In some the sac is so large as to fill the abdomen of the fetus and to present serious or insuperable obstacles to normal delivery. In others, when the stricture or other obstruction is incomplete, no tumor may be observed at birth, and only at a later period will the hydronephrosis become manifest, so that it may be hard to say whether the original causation was congenital or acquired. A case of congenital displacement of the kidney, in which the hydronephrotic condition gave symptoms only after the thirteenth year of life, was operated upon in the Roosevelt Hospital in 1894; it is mentioned in the section on Congenital Defects and Displacements of the Kidney. It is interesting to note that the character of fluid contained in congenitally hydronephrotic kidneys does not always permit a positive diagnosis of the condition; in the cases born with absolute obstruction *urea* may be absent, or present only in minute quantity.

Acquired Obstruction Causing Hydronephrosis.—As stated, those causes of obstruction to the flow of urine which are so placed as to operate upon both kidneys, though exceedingly common, do not, as a rule, afford physical signs, such that a definite diagnosis of hydronephrosis is possible, nor is the hydronephrotic condition itself directly amenable to surgical treatment. A palpable abdominal tumor is rarely formed, and our surgical efforts must usually be directed to the seat of obstruction in the bladder, the prostate, the urethra, etc. A considerable proportion of these cases are due to pressure upon or invasion of the ureters by cancers originating in the uterus at a period of the disease when surgical relief is no longer possible; a certain number to inflammatory exudates in the female pelvis. The conditions, on the other hand, affecting but one kidney, due to obstruction of a single ureter, are of great surgical interest, and the results of operation are often brilliant, notably when conservatism and the preservation of the kidney is still possible.

Other Causes.—Some of the causes of unilateral hydronephrosis are: Compression of a ureter by inflammatory exudates in the female pelvis, or by inflammatory peritoneal bands; compression or kinking by a retroflexed or otherwise displaced uterus; compression by an anomalous renal artery or by an accessory ureter; pressure from enlarged lymph nodes and other pelvic tumors, whether malignant or benign. Inflammations of the ureter itself—gonorrheal, tuberculous, proliferating, leading to the formation of stricture. Tuffier especially called attention to the frequent formation of stricture of the ureter resulting from gonorrheal infection. Ordinary pyogenic infections

or around the ureter. Impaction of calculi in the ureteric pelvis or in the eter itself (a frequent cause). Inflammations and ulcerations of the ureteric ifice in the bladder. Stones and tumors of the bladder. Cystitis. Kink- ig and valve formation from movable kidney. Traumatisms of the ureter. A few cases have been observed where, by blocking of a single calyx, a por- ion only of the kidney has become hydronephrotic, and in cases of double ureter, one of which has become blocked, a similar condition has been ob- served.

Signs and Symptoms of Hydronephrosis.—From whatever cause arising, the history of the development of a condition of hydronephrosis will vary in differ- ent cases, largely according to whether the obstruction of the ureter takes place slowly, gradually, and continuously, or is, on the other hand, sudden and com- plete, but intermittent; or whether, at first being partial, it finally becomes complete and permanent.

In the first group of cases no very marked symptoms may occur until a con- siderable tumor has formed in the loin and begins to produce symptoms by pressure on surrounding organs; a constant sense of fullness and dragging in the loin, occasionally accompanied by attacks of pain in the back radiating downward along the ureter to the external genitals (renal colic)—as when the tension of the sac is temporarily increased by an unusual secretion of urine or by more complete obstruction. Pressure symptoms on the stomach and colon appear when the tumor reaches a certain size, and consist of loss of ap- petite, indigestion, nausea, vomiting, and constipation.

When the tumor has reached a sufficient size it will occupy the space in front of the lower ribs, to one side of the spine, and project forward below the costal arch, forming usually a more or less tense, elastic swelling of rounded, smooth, or sometimes lobulated outline. Upon bimanual palpation a sense of increased tension in the sac may usually be perceived by the anterior hand when pressure is made with the other below the ribs posteriorly. In slender persons it is sometimes possible to distinguish areas of greater or less resistance, corresponding to thicker or thinner portions of the sac, or even to make out an uneven or lobulated surface corresponding to the separate dilated calyces. In congenitally misplaced kidneys and some hydronephrotic movable kidneys the position of the tumor may be lower down. The relation of the colon to the tu- mor, as in other renal enlargements, is usually characteristic—namely, the bowel crosses the front of the kidney, either vertically or obliquely, or, if the sac be very large, may lie to its inner side. As the sac increases in size it dis- places the diaphragm upward, displaces the ribs outward, extends downward as far as, or into, the pelvis, and may extend well across the median line, so completely filling the abdomen as to render a differential diagnosis from ascites difficult. Thus, a case which I saw in the service of Dr. Charles McBurney, at Roosevelt Hospital, in 1891—an infected hydronephrosis—the following details of the history may form a useful illustration of an extreme degree of hydronephrosis:

The patient was a man, aged twenty-eight years. Twelve years before, he had commenced to have attacks of pain in the left side of his abdomen. Two years later he first noticed a slowly progressive enlargement of that side of the belly; this had continued to increase. He was poorly nourished, anemic, and slightly septic. Chief complaint, physical weakness and discomfort on account of the size of his abdomen.

Physical Examination.—The abdomen was greatly enlarged. A large, tense, smooth tumor occupied the entire left side of the belly and extended eight inches beyond the median line toward the right. The tumor was flat on percussion. Inflation of the intestine with gas demonstrated a movable coil of intestine overlying the tumor and passing from the right hypochondrium to the left inguinal region. The aspirating needle withdrew a light brownish fluid, resembling in color the urine passed *per urethram*. Upon boiling, the fluid coagulated, and when burned gave off a urinous odor. The fluid contained pus, uric acid, and urea. There was slight frequency, but urination painless. Urine cloudy, brown, acid; specific gravity, 1.025; much albumin, and contained much pus, red blood cells, and renal epithelium. At short intervals the tumor was aspirated, and urine mixed with pus was withdrawn to the amount of 90, 138, and 238 ounces; soon thereafter a portion of the cyst wall was excised and the sac drained. His general health was soon greatly improved. He remained under observation for several months and was then lost sight of. When last seen he still had a sinus.

Large hydronephrotic sacs are usually rounded, have a smooth surface, and give plainly the sign of fluctuation characteristic of cystic tumors containing fluid; such is, however, not always the case; when the sac is of smaller size the contents may be under great tension; the tumor may be irregular or lobulated in shape, and the sensation transmitted to the examining hand may be that of a hard solid growth; dullness on percussion is common to both conditions—i. e., to cysts and solid growths. The fact that hydronephrotic kidneys are nearly always tender when deeply pressed upon, whereas, true new growths of the kidney are rarely so, is a differential point of value. Since well-marked hydronephrosis leads, sooner or later, to total atrophy of the secreting structure of the kidney, individuals who suffer from simultaneous or successive distention of both kidneys inevitably die of uremia, and yet if one kidney is first affected, the other will usually have undergone hypertrophy, and if it becomes hydronephrotic may still contain a large amount of kidney substance although distended to enormous size. If, then, the history points to the successive involvement of the two organs, the successful operative treatment of the one last affected may still be possible; a suitable channel may be constructed to the bladder and the patient saved.

Intermittent Hydronephrosis.—In the cases where the obstruction is more or less intermittent certain rather characteristic signs and symptoms occur. Intermittent hydronephrosis is more apt to occur when the obstruction is due to the presence of a stone at the junction of the ureter with its pelvis acting as a ball valve, and in cases of movable kidney which develop ureteral angulation or valve formation. In these cases marked symptoms occur before the forma-

tion of a palpable tumor, in many, indeed, no evident tumor is ever formed. The symptoms consist of attacks of renal pain with the accompanying nausea, vomiting, prostration, etc., with more or less marked oliguria or anuria. After hours or days the pain suddenly subsides and the patient passes a large quantity of urine, usually of low specific gravity. If calculus be the cause such urine will often contain blood, sometimes pus; if an infectious lesion be present the quantity of pus may be large. In the cases presenting a palpable tumor the attacks of pain will be accompanied by the formation of a swelling in the loin, tender on pressure, which diminishes in size or disappears as the attack subsides and, as in other cases, a large amount of urine will be passed. This characteristic train of events establishes the diagnosis clearly.

The following case, seen in the service of Dr. Charles McBurney at Roosevelt Hospital in 1897, illustrates well the history of an intermittent hydronephrosis caused by a renal calculus acting as a ball valve at the junction of the ureteric pelvis with the ureter:

The patient was a female, aged forty-eight, admitted June, 1897.

Present Illness.—In 1891 a single well-marked attack of renal colic and the passage of many small pin-head-sized calculi.

Three years ago, following unusual muscular effort, patient had a dull pain in right lumbar region and a large mass developed in the right loin. All these symptoms vanished after a night in bed. The attacks have recurred at intervals of from three to six months, and their subsidence has been coincident with the passage of a large amount of urine. For past nine months the attacks have been more frequent—every ten days. They have been accompanied by chills, nausea and flatulence, dull pain in right lumbar region and right side of abdomen, and a sensation of fullness and dragging. The tumor was less prominent after rest in recumbent position, but of late the diminution in size has been less marked. Last attack was three weeks ago. The mass in loin was very large, but after three days in bed almost disappeared. Urine amber, acid; specific gravity, 1.012; albumen a trace. The quantity passed in twenty-four hours varied very much from day to day, being sometimes much above the normal and on other days very small in amount.

Physical Examination.—Patient was well nourished and healthy in appearance. The right side of the abdomen was prominent. A large tumor was made out occupying the whole right side of the abdomen and extending beyond the median line. It was rounded, surface smooth and tense; the tumor was somewhat movable and obscurely fluctuating—not tender. On percussion, dullness continues with the percussion note of the liver. Temperature, 100° F.; pulse, 84.

Operation by Dr. McBurney, June 25, 1897. Cut from one inch below the tip of eleventh rib inward to outer border of right rectus, describing a curve convex downward. Muscles divided in line of the incision and peritoneum opened. Hand introduced into the peritoneal cavity and the left kidney palpated. It felt normal. Peritoneum then pushed away to the median line and the large cystic tumor exposed. On account of its great size the incision was enlarged by a vertical cut along the outer border of the rectus as far downward as the level of the

anterior superior spine. Peritoneum was stripped off the front of the cyst toward the median line. The tumor was enucleated by blunt dissection with the hands and delivered through the wound. Ligature of renal vessels with catgut and a clamp applied to them nearer the kidney. Ureter cut between catgut ligatures. Lower end of ureter cauterized before the lower ligature was tightened. Vessels cut and ureter and tumor removed. Suture of wound, except the outer two inches of horizontal part, left open for drainage by gauze packing.

Pathological Report.—Cystic tumor of renal origin. Twelve by six by six inches. The sac is fully distended with clear yellow fluid to the amount of many ounces. Something like the shape of the kidney, but elongated. Pelvis dilated. Surface of tumor smooth, with large rounded elevations corresponding to a series of irregular intercommunicating chambers in the interior. The wall is of variable thickness, in some situations quite thin. Within the cyst are a number of spherical calculi of buckshot size. One or other of these calculi has, from time to time, lodged at the entrance to ureter and, acting as a ball valve, has allowed the escape of a variable quantity of urine at different periods, depending upon the position assumed.

Wound Healing.—Moderate suppuration of lower part of vertical wound quite superficial. Wound soon cleaned, and patient left hospital with wound healed and in good health, August 18, 1897.

Subsequent History.—Remains in perfect health at the present writing.

Another case of intermittent hydronephrosis caused by a kink in the ureter of a movable kidney will serve to illustrate a type of the condition curable in its earlier stages by a conservative operation.

The patient was a woman who came under my care in the New York Hospital; she was twenty-nine years old, married, and the mother of five children. During several years she had suffered from attacks of abdominal pain, accompanied by nausea, vomiting, and prostration. The pain was referred to the region of the umbilicus and did not radiate downward. The attacks lasted hours or days and subsided suddenly; the cessation of pain was accompanied by polyuria. The attacks occurred at irregular intervals. Menstruation and physical exercise sometimes brought them on; between the attacks she was entirely free from discomfort. Her abdominal walls were thin and relaxed, and she had observed a mass to the right of the median line at the level of the umbilicus. The tumor became larger and tender during the attacks. Her urine had always been clear, and examination showed it to be entirely normal.

Physical examination permitted one to feel a freely movable, kidney-shaped tumor, nearly in the middle line at the level of the umbilicus. Upon palpating the kidney through a cut in the loin the organ was found lying transversely in the belly, the hilum directed upward. The pelvis and calices were much dilated, the sinus of the kidney much enlarged. By invaginating the pelvis with the fingers the substance of the organ could be felt thinned out to half its normal thickness. The kidney was moderately enlarged. Upon displacing the kidney downward a sharp angulation at the junction of the pelvis with the ureter was readily produced, such that the lumen of the tube appeared to be completely obstructed. The kidney was sewed to the muscles of the loin in the best attainable position by

stripping the *capsula propria* and sewing its cut edges to the edges of the cut muscles. The patient never had another attack of pain after the operation and has remained well.

Closed Hydronephrosis.—In the group of cases that eventuate in a complete and permanent closure of the ureter the intermittent character of the tumor will be absent and the urine passed will be normal, assuming that the other kidney is healthy. The contents of these permanently closed hydronephrotic sacs consists, so long as any proper secreting kidney tissue remains, of urine, more or less altered in character, of low specific gravity and poor in urea, uric acid, and salts. When total atrophy of the kidney has occurred, usually only after years, still further changes may occur: urea and uric acid may disappear; the contents may then consist of watery fluid containing a little albumen and but little sodium chloride; cholesterin crystals may form in the sac; the fluid may take on a colloid character; the fluid may be brown or greenish in color from the remains of blood pigment. If infection of the interior of the sac occurs there will be an admixture of pus.

Whether a large closed hydronephrosis is capable of spontaneous cure is questionable; such cases have, however, been reported. In the cases due to stone or the kinking of the ureter, the passage of the stone into the bladder may be followed by cure, although in these stricture of the ureter may follow from inflammation or ulceration caused by the stone.

Traumatic Hydronephrosis.—As the result of blows or falls upon the abdomen the ureter may be crushed in such a manner that the healing process is followed by stricture, or even complete obliteration of the canal, and a hydronephrosis which develops within a few weeks or in some cases not for several years. Some of these cases have been attended by hematuria at the time of the accident, some have not. In other instances the trauma has been followed by a large peri-ureteric hematoma and the healing process has eventuated in the production of cicatricial tissue so situated as to compress and occlude the ureter. The cases of traumatic hydronephrosis reported are not very numerous but are of undoubted authenticity. The history, together with the characters of the condition, as described, suffice for the diagnosis. Trauma to a large existent hydronephrosis is a very dangerous accident. The sac may be ruptured into the perirenal tissues or into the peritoneal cavity. The dangers are perirenal septic inflammation or diffuse peritonitis, as the case may be; a third danger is serious hemorrhage, either into the sac or into the perirenal tissues.

Differential Diagnosis of Hydronephrosis.—We shall consider this topic again when describing the diseases of the ureter and bladder; here it may be said that large hydronephrotic cysts may be mistaken for several other cystic formations, most often for *ovarian cyst*. The differential points are as follows: A large ovarian cyst occupies a nearly central position; a hydronephrosis, even though it may extend beyond the middle line, does not occupy a strictly central position in the belly. The inflated colon lies in front of a hydro-

nephrotic sac, in all but enormous dilatations, when it may lie to the inner side. Ovarian cysts only very rarely have intestinal coils in front of them. The relations and attachments of the tumor to the uterus and its adnexa may sometimes be made out in doubtful cases by seizing the cervix with a volsellum forceps and drawing it strongly downward toward the vulva; the uterus and adnexa are then palpated *per rectum*, and their mobility and freedom from attachment to the tumor or the contrary may thus be determined. In some cases a calculus may be felt in the lower end of the ureter, making the diagnosis of hydronephrosis almost certain.

As already noted, hydronephrosis of a congenitally misplaced kidney will, in the absence of a history of urinary symptoms, nearly always lead to an error in diagnosis. *Echinococcus cyst* of the liver may be mistaken for hydronephrosis; the former has usually a very long history, is immovable, and can in no wise be differentiated from the liver. If movable, echinococcus cyst of the liver will have a vertical respiratory mobility. Hydronephrosis of the kidney, if not enormous, will usually be movable laterally, sometimes vertically as well, and percussion and palpation will usually permit differentiation from the liver. For the characters of gall-bladder tumors, see Diagnosis of Abdominal Tumors; also Diseases of the Gall-bladder.

It is often impossible to determine before operation whether a hydronephrotic sac is infected or not. In the presence of chronic septic symptoms such infection is probable, but in all closed hydronephrotic sacs with thickened walls chronic suppuration may occur without much absorption, and septic symptoms may be entirely absent. Certain other conditions may be mistaken for hydronephrosis; **perinephric suppuration** is usually rather an acute process, is accompanied by marked sepsis, fever, an accelerated pulse, an increase in the relative number of polymorphonuclear white blood cells, etc. The local signs of acute inflammation are present in the loin, or soon develop—pain, tenderness, later redness of the skin. The swelling is not a sharply circumscribed tumor but a hard or boggy diffuse infiltration. Following trauma a **perirenal extravasation** of blood or urine, or both, forms a painful tumor immediately, or within a few days. A hydronephrosis following trauma develops slowly, after weeks, months, or years. Very large thin-walled hydronephrotic sacs have been mistaken for **ascites**—the two may coexist. An incision is the surest differential guide.

In cases where no positive diagnosis can be made, an exploratory incision at a convenient point, to be followed by an operation to suit the individual case, is the surest and safest diagnostic measure; safer far than aspiration, unless the needle be introduced at a point certainly outside the peritoneum. The fluid withdrawn by aspiration may, if of a distinctly urinous character, establish a diagnosis of hydronephrosis at once; on the other hand, if, as already pointed out, in old closed sacs, urea, etc., may be absent and, moreover, ovarian fluid may occasionally contain a small amount of urea. The point at which an exploratory incision should be made will, of course, depend upon the

ividual case; if the probabilities are in favor of an ovarian cyst it may be le in the middle line in front; if, on the other hand, it seems probable that growth is connected with the kidney, or is at least retroperitoneal, a cut ow and parallel to the ribs in the loin is a more suitable site. If the cut be nd unsuitable for further operative measures, as indicated, it should be sed and another made at a more favorable site.

CHAPTER XV

SUPPURATIVE LESIONS OF THE KIDNEY

Pyelitis—Pyelonephritis—Abscess of the Kidney (Suppurative Nephritis)—Pyonephrosis

Pyogenic infections of the kidney are very frequent; the lesions are varied and form a group of conditions of great interest to the surgeon. The severity and destructiveness of the infection may be moderate, a purulent inflammation of the mucous membrane of the renal pelvis and ureter (*pyelitis*). In other cases solitary or multiple foci of suppuration occur in the parenchyma of the organ (*abscess of the kidney—acute suppurative nephritis*). In other cases the kidney substance, the pelvis, and ureter are all involved (*pyelonephritis*). In still others the lesion is partly an obstructive one, leading to distention of the kidney, the formation of a sac lined with a pyogenic membrane, and more or less complete destruction of the parenchyma of the organ by the combined effects of suppuration and pressure (*pyonephrosis*). The lesions may remain confined to the genito-urinary tract or may perforate and cause perirenal suppuration (*perinephritis—perinephric abscess*). The several lesions may exist alone or one may pass into another, or they may be combined in a variety of ways, to be described.

Varieties of Pyogenic Germs Found in Suppurative Lesions of the Kidney.—The most varied forms of pyogenic organisms may infect the kidney, the most common invader being Bacillus coli. Among others may be mentioned the pyogenic staphylococcus and streptococcus, the gonococcus, Bacillus typhosus, the Tubercle bacillus, Bacillus pyocyaneus, Bacillus tetragenus, the diplococcus of lobar pneumonia and the bacillus of diphtheria—indeed, nearly all of the bacteria capable of producing suppuration have been demonstrated in suppurative kidney lesions. When we bear in mind that in all generalized bacterial infections the kidneys are one of the most important avenues through which germs are eliminated from the body it is easy to see that in the kidney itself such organisms may find a favorable soil for further development.

Modes of Infection.—Infection of the kidney may occur by the extension of an inflammatory process of the lower genito-urinary tract upward from the bladder to the ureter, thence to the renal pelvis, and, finally, to the substance of the kidney—*urogenous infection—ascending infection*; or by the arrest in the kidney of organisms circulating in the blood—*hematogenous infection*. It was

ormerly believed that this mode of infection was rare. At present we know hat it is very frequent.

Ascending infection takes place as an extension from the urethra and bladder in gonorrhea (gonococcus, Bacillus coli); very commonly in cases of acute and chronic cystitis with prostatic or ureteral obstruction (Bacillus coli); indeed, in prostatic enlargement with residual urine and cystitis, such an infection is one of the regular developments of the later stages of the disease. In certain cases we remain in doubt as to the exact mode in which pyogenic germs have reached the kidney, since, in the presence of a cystitis, a patient may develop a suppurative nephritis the character of which, and the distribution of the lesions, being such as to render a hematogenous infection probable, the changes in the renal pelvis and ureter being very slight (Lennander). The *hematogenous infections* of the kidney may be secondary to a great variety of generalized specific infections or to almost any localized pyogenic focus in a distant part of the body. Among the former group may be mentioned the acute exanthemata, typhoid fever and diphtheria; among the latter, erysipelas, osteomyelitis, furunculosis, and suppurative tonsillitis. In the course of generalized pyogenic infections—pyemia, puerperal sepsis, malignant endocarditis, etc.—metastatic infection of the kidney is exceedingly common; further, as the result of trauma to the kidney or ureter.

A physical condition of great importance favoring the occurrence of infection is any obstructive lesion of the lower genito-urinary tract with its attendant stagnation of urine—stricture of the urethra, prostatic hypertrophy with residual urine, the blocking of a ureter by stone, stricture of the ureter, kinking as the result of movable kidney. Inflammation of the ureter—pyogenic, gonorrheal or tuberculous—causing a narrowing of its caliber. Trauma to the kidney, either recent or remote in time, may predispose to infection by forming a point of diminished resistance or a point of obstruction. Further, compression of the ureter from without by the pregnant uterus, by cancer, or by any tumor; and, lastly, an existent hydronephrosis. All these obstructive lesions predispose to infection, and when such infection has occurred, render its destructive effects more certain and more rapid. Many of these infections are of the ascending type.

Pathological Anatomy.—In order that the diagnosis of kidney suppuration may be studied intelligently some knowledge of the various lesions which occur in the kidney as the result of pyogenic infection is necessary; accordingly, a brief outline is here given, partly adapted from Schede.

The invasion of the kidney substance with pyogenic germs by way of the blood current is followed by a lesion closely resembling in appearance a pyemic embolic infarct. A focus of purulent infiltration is produced in the kidney cortex, ovoid, or somewhat wedge-shaped, having its face directed toward and extending to the *tunica propria* or kidney capsule. The blood-vessels of this area are filled with bacteria, the interstitial connective tissue is infiltrated with red and white blood cells. The base of the wedge causes a slight flattened prominence upon the

kidney surface, and upon inspection minute yellowish dots may be distinguished consisting of very small abscesses. Upon section similar dots may be seen scattered throughout the affected area. Such minute abscesses often surround a glomerulus. The entire area is surrounded by a hyperemic zone of bloody infiltration forming a sharp dividing line from the noninfected tissue. Softening of the focus, as a whole, produces, after a variable time, an abscess; and coalescence of several foci an abscess of larger size. If many such foci are present the entire kidney cortex may be studded with abscesses. If the process is diffuse the kidney is notably swollen, each abscess being marked upon the kidney surface by a rounded swelling. The remainder of the kidney usually shows the lesions of an acute exudative nephritis. The epithelium of the tubules is in a condition of cloudy swelling or of fatty degeneration; the tubules are filled with cast materials; the interstitial tissue shows marked small-celled infiltration. At a late stage of the process, when the abscesses have grown large, the kidney comes to consist of a series of abscess cavities whose walls are formed by a meshwork of whatever remains of the degenerated kidney tissue. The fatty capsule of the kidney becomes infiltrated with new connective tissue and is indurated; much of the fat disappears.

In some cases an abscess breaks through the kidney cortex; it may remain confined beneath the fatty capsule or perforate it and cause purulent infiltration of the surrounding structures (perinephric abscess). If an abscess breaks into the renal pelvis, pus appears in the urine in quantity; the pelvis and ureter become infected, their lining membrane thickened and swollen, leading to urinary obstruction.

By pressure an abscess may have already obstructed the ureter. Or one of the septa remaining between the several abscesses may come to overlie and close the ureteric orifice like a valve; the remaining kidney parenchyma, still capable of functionating, continues to secrete a little urine—thus the renal pelvis is distended with a mixture of pus and urine. As the result of increased pressure the remaining kidney tissue undergoes more complete atrophy; gradually the septa between the several abscess cavities disappear and the kidney is converted with its pelvis into a single large sac containing pus and urine, with more or less smooth walls, rounded prominences on its surface alone remaining to indicate the original multilocular character.

In other cases the microbes do not plug the blood-vessels of the kidney cortex, but escape through the convolutions of the glomeruli into the collecting tubules along with the urine and here multiply (*nephritis papillaris mycotica*), so that one might speak of a nephritis of bacterial elimination. In the very early stages of this form there may be seen fine gray or grayish-yellow streaks following the course of the straight tubules. In the vicinity of the apices of the papillæ these streaks may be so closely grouped as to form a more diffuse dirty yellow or brown discoloration, in which certain thicker streaks are more noticeable (Orth).

Microscopically the uriniferous tubules are seen filled with bacteria, the epithelia in a state of fatty degeneration or of necrosis, and true suppuration occurs only beyond this layer. If the kidney is infected by an ascending inflammation from the bladder, ureter, or pelvis, the first changes are, as might be expected, in the papillæ; later on in the medullary layer; finally in the cortex. In severe cases the entire kidney is hyperemic and enlarged and shows numerous minute punctate hemorrhages in its substance. The boundaries between the cortex and the

medullary layer are obscured. Suppuration usually occurs in the pyramids with the formation of abscess, with which goes, hand in hand, a necrotic process. Thus minute necrotic portions of the papillæ may be discharged with the urine. In some cases minute abscesses also form in the cortex. The subsequent series of events does not materially differ from those described when infection occurs through the blood. (See also Pyonephrosis.)

Clinical Manifestations, Course, and Diagnosis of Pyogenic Infections of the Kidney.—As might be expected, the clinical picture varies greatly according to the mode of infection, the character and extent of the lesion, the presence or absence of urinary obstruction, and other causes to be mentioned. In general, the hematogenous infections are characterized by a more sudden onset and more acute symptoms than is the case in ascending infections.

The Hematogenous Pyogenic Infections.—In this group of cases the symptoms referable to the kidney will have been preceded by some acute infectious disease, or some localized focus of suppuration elsewhere in the body, or by a subcutaneous injury to the kidney region, by pregnancy, parturition, etc. In some cases the patient will have a chill, fever, a rapid pulse, prostration, and other general symptoms characteristic of septic processes. In addition he will have an attack of typical colic, probably due in a large proportion of cases to hyperemia of the kidney and increased intracapsular tension. Examination will elicit marked tenderness of the kidney on palpation; in some cases at the end of a very few days the kidney will be increased in size and, in favorable subjects, distinctly palpable. At this time the urine may contain pus, red blood cells, and bacteria; or bacteria but no pus; or it may be practically normal.

In a series of cases reported by G. Brewer ("Acute Unilateral Septic Infarcts of the Kidney," *Surgery, Gynecology, and Obstetrics*, May, 1906), records of urinary examination were made in 11 out of 13 cases reported. In 1 the examination was negative. Ten specimens contained albumin; 5 contained albumin and a small amount of pus; 5 albumin, pus, and blood. In all but 1 case the blood occurred in microscopical amounts merely. In 3 cases the separated urines were examined. In each of these the specimen from the side of the lesion contained albumin, pus, and blood."

As an instance of acute and probably hematogenous infection of the kidney giving early symptoms sufficient for a diagnosis, I will relate the history of a woman upon whom I operated in 1901. In this case the original infection may have been through the bladder, and yet the character and distribution of the lesions were such as to make me believe that the kidney was infected through the blood rather than by extension of the inflammatory process from the bladder through the ureter. In the cortex alone were found marked lesions, and these of a type characteristic of an embolic process.

The patient was a woman, twenty-eight years of age, a Jewess, the mother of six children; she was admitted to the New York Hospital August 10, 1901. Seventeen days before, she had given birth to a child. The confinement was nor-

mal, but she suffered from retention of urine and was catheterized for three days; she then began to suffer from frequent and painful urination, and two or three days later she was suddenly seized with a severe pain in the left hypochondrium. Ten days after confinement she was seriously ill. She had frequent chills, high fever of a septic type, restlessness, and extreme prostration. On admission to the hospital she looked markedly septic. Temperature, 105° F.; pulse, 120. Her tongue was dry and covered with a brown coating. She had frequent sweats. Pain on urination and frequency had ceased. She complained of pain and tenderness in the left hypochondrium and loin. Muscular rigidity of the abdominal wall of that side was so marked that proper palpation was impossible. There was marked tenderness at the costo-vertebral angle of the left side. Her urine showed very little that was abnormal; its quantity was somewhat diminished; there was a small amount of albumin; specific gravity low; under the microscope a moderate number of pus and blood cells.

The following day the left kidney was removed by a lumbar incision parallel with the ribs. The fatty capsule of the kidney was edematous. There were numerous groups of submiliary abscesses visible upon the kidney surface. On section the characteristic wedge-shaped areas of infiltration could be seen extending to the medullary layer. The entire kidney was markedly hyperemic. The infiltrated areas had not, as yet, broken down. The mucous membrane of the pelvis and calices was practically normal. The patient's convalescence was rapid. The septic symptoms rapidly disappeared. Her temperature, which had been 105.2° F. at the time of the operation, dropped in a few hours to 99° F., and only rose once as high as 102° F. thereafter. The right kidney continued to functionate perfectly. She left the hospital on the twenty-sixth day quite well, and has since borne two children without serious trouble.

Bilateral Infection.—In the cases involving both kidneys the conditions are far less favorable. If the infection of both organs is simultaneous and acute, these patients may, in addition to profound septic symptoms, soon develop the typhoid and, later, the uremic state, with diminished, albuminous urine, or anuria, vomiting, headache, stupor, coma, convulsions, and death. The anuria may be due to the intense nephritis or, in other cases, to obstruction of both ureters from one or other mechanical cause. In some cases the septic symptoms will predominate, the patient will continue to pass urine of low specific gravity containing some pus and a diminished quantity of urea; there will be no convulsions, and coma will occur only shortly before death. The general symptoms may so far overshadow those referable locally to the kidney that in the absence of an evident lesion of the lower genito-urinary tract the diagnosis may not be made.

The most acute cases sometimes follow surgical operations on the urethra for stricture, or on the prostate and bladder, notably in the presence of a chronic cystitis, and it was to them that the name "*surgical kidney*" was formerly applied. The operation need not have been severe, the passage of a catheter or the introduction of a sound being even more likely to determine the dissemination of the infection than an operation which, though

extensive, has provided adequate drainage for the urethra and bladder. Though many of these cases belong to the ascending type of infection, others, no doubt, are hematogenous. Still others are a pure septicemia without a definite localization in the kidney. The differential diagnosis from general septicemia can only be made in these cases by detection of pain and tenderness on palpation over one or both kidneys, or by the additional sign of the presence of a renal tumor. The urine would rarely furnish positive diagnostic aid unless the ureters were catheterized, since pyuria would usually be present in both conditions. In some of these cases in old men one sees anuria and a combination of acute sepsis with uremia such that the infection of the kidney is often overlooked. (See also Urethral Sepsis, etc.)

Frequency of Unilateral and Bilateral Infections.—The relative frequency of single and double embolic infections of the kidney it is not easy to discover. I have been unable to find any statistics upon this point; but my own experience would lead me to believe that one kidney is alone involved in a large proportion of cases—probably more than half. Dr. Joseph A. Blake informs me that in his experience seventy-five per cent of the cases are unilateral in the beginning. If early surgical relief is not afforded and the patient survives for a time, the other kidney becomes infected secondarily in a good many cases, either by an ascending infection or through the blood.

Early Diagnosis of Unilateral Embolic Kidney Suppuration.—The early diagnosis of unilateral embolic kidney suppuration is very important, since, in bad cases, prompt operation—usually nephrectomy—is necessary for preserving life. In some cases where a solitary focus exists, or but few foci are formed, excision of the infected area and free drainage may be sufficient. An early diagnosis is, however, not always easy; to recapitulate, the following are the data upon which we must depend:

Women are more often affected than men—in Brewer's cases eleven were females, two were males. The patient will have had some acute infectious disease—scarlatina, measles, typhoid, or other; or some acute suppurative lesion—furunculosis, a carbuncle, osteomyelitis, etc.; or a history of injury to the kidney, recent or remote; or a wound of or operation upon the kidney or upon the lower genito-urinary tract—perhaps a fistula leading to the renal pelvis or ureter; or she will be pregnant or in the puerperal state, and will suddenly be seized with the general symptoms of acute sepsis—a chill, high fever, a rapid pulse, prostration, and a high polynuclear leucocyte count. The urine will nearly always contain albumin, pus, and sometimes blood in small amount. The ureteral catheter will show that one kidney is excreting less urine than the other and will show the presence of pathological ingredients upon the affected side. In these very acute cases it is unlikely that cystoscopic examination of the ureteral orifices would afford reliable information in the average case.

There will nearly always be pain, sometimes referred to the loin, and of the type of renal colic. In other cases the pain will be referred to one side of the abdomen or to the iliac region, so that if upon the right side appendicitis will

be diagnosticated. The pain may be central in the abdomen or without definite localization. There will be tenderness upon palpation of the kidney region—usually in front, and always behind, over the last rib, or at its junction with the spine. There will be nearly always abdominal rigidity, often very marked, over the affected organ. Palpable enlargement of the kidney will usually be absent during the early stages of the disease, for, although the kidney is swollen, abdominal rigidity will prevent its recognition except under a general anesthetic—still, it may sometimes be felt in thin and flabby subjects. Such a train of symptoms and signs will justify the surgeon in exploring the suspected kidney.

Subacute Cases.—In another group of cases primary pyogenic infection of the kidney runs a far less acute course. The onset may be insidious, there may be no pain, or only dull pain in the loin, or a sense of dragging and fullness. Continuous or intermittent pyuria may be the only local sign to point to disease of the genito-urinary tract; or these patients will suffer from frequent and painful urination. They are often treated during long periods for cystitis. In a large proportion of these cases symptoms of chronic sepsis are more or less marked. The patients will have an evening rise of temperature, occasionally chilly sensations, or chills and sweating. They become anemic, suffer from loss of appetite and of flesh. In some cases constitutional disturbances—fever, etc.—are associated with attacks of renal pain and with retention of urine in the infected kidney. If during these attacks the patient passes clear and normal urine, followed by marked pyuria and synchronous subsidence of the fever, etc., the diagnosis of a unilateral kidney or ureteral lesion is quite plain. During the period of retention there will usually be tenderness over the kidney and in some cases a palpable tumor. A somewhat similar series of events may occur when an abscess in the kidney ruptures into the renal pelvis. The patient may have suffered from pain and tenderness in the kidney region with more or less marked sepsis with or without palpable tumor; suddenly a very marked pyuria will occur, often with temporary abatement of the septic symptoms, and diminution in the size of the tumor—if such existed.

Cystoscopic Examination and Ureteral Catheterization as an Aid in the Diagnosis of Suppurative Kidney Lesions.—In these cases cystoscopic examination of the ureteral orifices often gives valuable information. The urine from the affected kidney, as seen gushing in intermittent jets from the orifice of the ureter, may be distinctly purulent. Such a finding is only possible in a moderate proportion of cases, since a perfectly clear field is not always obtainable, notably when a cystitis exists, the presence of pus and shreds in the bladder, leading sometimes to a misinterpretation—i. e., the pus lying near the ureteral orifice may be stirred up by the jet of urine, and the examiner may falsely assume that the cloudy material has escaped from the ureter. On the other hand, in old cases, and notably in females where examination with Kelly's tube is easy, I have repeatedly made the diagnosis of a unilateral lesion by watching each ureteral orifice, and observing pus coming

from one, clear urine from the other. In the cystoscopic field one may sometimes see a plug of muco-pus protruding from a ureteral orifice. In pyogenic affections of the kidney changes in the appearance of the ureteral orifice may also be observed, and, while not so constant or characteristic as in cases of tuberculosis, they are, nevertheless, valuable. Thus, W. C. Klotz (*Surgery, Gynecology, and Obstetrics,* May, 1906, "Diagnostic Significance of Ureteric Meatoscopy in Renal Disease," p. 500) says:

> The second group comprises thirteen cases of pyogenic infection of the kidney resulting either in pyonephrosis or pyelonephritis. Changes in the ureteric orifice were noted in eight. These changes consisted either in an increase in size of the orifice, with infiltration and ulceration of the lips, and more or less swelling and redness of the surrounding mucous membrane or of the entire trigone, or the ureteric orifice was contracted, round, puckered up; the lips more markedly infiltrated, appearing even indurated, and the mucous membrane of the adjacent portion of the trigone presenting a dark-red, smooth appearance.

The ureteral catheter gives, however, positive and reliable results in all cases where it can be used. (See section on Ureteral Catheterization and below.) In some cases one or other form of urinary separator may give satisfactory information. (See section on this topic.) In other cases where, on account of cystitis, stricture of the urethra, a large prostate, or other difficulty, we are unable to use the cystoscope, other diagnostic aids are available. Thus, we may sometimes differentiate renal pyuria from cystitis by the following procedure (Thompson): If pus is coming from the kidney, and the bladder is repeatedly washed with saline solution through a soft catheter, the urine, subsequently allowed to accumulate in the bladder during ten minutes and withdrawn, is as purulent as before. If the source of the pus is the bladder itself, the urine remains comparatively clear for some little time.

True and False Albuminuria.—Another important problem in pyogenic infections of the genito-urinary tract, especially in those where infection of the kidney is suspected, and where the question of operation arises, is to distinguish between an albuminuria due merely to the presence of pus in the urine and an albuminuria due to a lesion of the kidney itself, conditions known as true and false albuminuria respectively; the question is one not always easy to answer. If, in the presence of pyuria and in the absence of any physical signs of infection of the kidney and ureter, we, nevertheless, find in the urine the products of a chronic nephritis, granular casts, and especially pus casts—casts containing polygonal cells characteristic of the kidney tubules, or such cells in clumps or solitary, free in the urine—we can safely assume that a part, at least, of the pus has its origin in the kidney. But in the absence of such ingredients we cannot exclude disease of the kidney; the ureter may be temporarily or permanently closed, or the kidney may have entirely ceased to functionate.

Schlesinger formulated the following rules for distinguishing true from

false albuminuria; unfortunately, ammoniacal decomposition of the urine invalidates the method, and it is useful only when the urine is acid or neutral.

The pus cells in the urine are counted in the Thoma-Zeiss counting chamber. (See Blood.) A content of from 50 to 70,000 cells represents a quantity of albumin equal to 1 to 1,000 by the Esbach test; if, therefore, an albuminuria of 1 to 1,000 exists in the presence of only moderate pyuria it indicates a true—i. e., kidney—albuminuria. An albuminuria above 1 to 1,000 does not occur from pus alone (Schede).

Epithelia.—Considerable diagnostic importance has been given by certain pathologists to the occurrence in the urine of free epithelial cells of various types representing, upon anatomical identification, a definite source in the genito-urinary tract, and thus establishing the seat of an inflammatory lesion. With the exception of a few bladder cells in the male, and vaginal epithelia in the female, but few cells occur in normal urine. The epithelial cells from the straight tubules of the kidney, from the convoluted tubes, from the renal pelvis, the ureter, the bladder, and the urethra are believed by these pathologists to possess certain characters which permit a skillful microscopist to differentiate them fairly well, when free in urine. A number of very good pathologists deny this ability, but there are enough honest ones who believe that it can be done, to make it worth mention at least. Thus, if a purulent urine contains numerous cells which can be identified as belonging to the renal pelvis, a diagnosis of pyelitis may be made. Numerous bladder cells would indicate cystitis, and the presence of such cells in a state of fatty degeneration, or of cells identified as belonging to the deeper layers of mucous membrane, would indicate an intense or a chronic inflammation. A similar identification of cells belonging to the several varieties of renal tubules would locate the lesion in the kidney.

Without personal experience, I am inclined to the belief that careful pathologists regard the presence of cells of various types as confirmatory evidence merely, and would hesitate to base a diagnosis of an affection of any particular part of the genito-urinary tract upon such evidence alone. Dr. Frederic E. Sondern informs me in a personal communication that he bases no diagnostic reliance upon the mere form and size of free epithelial cells in pathological urine. The presence of such cells, taken in conjunction with other data, is, however, valuable confirmatory evidence under certain conditions. For example, if, in purulent urine, one finds a large number of epithelial cells the bladder is probably the seat of cystitis; if, on the other hand, marked pyuria exists, with but few epithelial cells, the kidney or the prostate are probable sources of the pus.

Operative Indications.—In deciding for or against an operation upon the kidney, in the given case, the surgeon should bear in mind that a septic nephritis of considerable severity may exist in one kidney without constituting an absolute contraindication to the removal of its fellow. Thus, Israel relates the history of a case of this character: A kidney was removed; it was the seat

of an intense septic inflammation, with numerous abscesses. A severe grade of nephritis existed in the other kidney at the time of the operation; the signs of nephritis, however, entirely disappeared, and the patient regained complete health; the removal of the septic focus permitted the other kidney to recover. A similar case came under my observation a few years ago:

A woman of middle age was operated upon by nephrotomy for a tuberculous kidney with secondary pus infection. The septic symptoms improved but did not disappear, and a pus sinus remained in the loin. At this time the patient came under the care of Dr. Charles McBurney, at whose request I passed a ureteral catheter into the ureter of the noninfected kidney. Examination of the urine thus obtained showed the presence of nephritis of a fairly severe type. The urine was of low specific gravity and contained a good deal of albumin with numerous granular and hyaline casts. The general condition of the patient was not good; she was anemic and feeble. Dr. McBurney removed the suppurating and tuberculous right kidney. The patient recovered, and at the end of a year was enjoying a degree of health which might fairly be called robust. The signs of nephritis had entirely disappeared, except that from time to time a minute trace of albumin was discovered in her urine.

These and similar observations teach us that the condition of the urine does not furnish an absolute measure of the capabilities of a disordered kidney to carry on its function, if we are able by the removal of its fellow to eliminate the cause of its faulty action. Many cases might be quoted in which an apparently severe nephritis caused by chronic suppuration in any part of the body has entirely disappeared after the septic focus has been removed by operation.

Clinical Characters of Pyogenic Infections of the Kidney Other than Acute and Subacute Hematogenous Infections.—Once developed, inflammations of the renal pelvis (pyelitis) and combinations of such inflammation with infection of the renal parenchyma (pyelonephritis) do not differ much in clinical characters, whether the infection has occurred through the blood or is the result of a local infection of the genito-urinary tract. The end results of these processes, however, acquired, may be kidney abscess, or pyonephrosis with or without perirenal suppuration. As already stated, urinary obstruction, from whatever cause, plays a very important rôle in the production of these lesions; this is especially true of pyonephrosis. Mild degrees of infection and very chronic kidney suppuration are much more common in the urogenous or ascending infections than in the hematogenous forms, though violent and quickly fatal cases also occur in these. Thus during pregnancy a mild catarrhal inflammation of the ureter and renal pelvis from pressure is not infrequent, congestion of the kidney being caused by pressure on the renal veins, obstruction to urination by pressure on the bladder and ureter.

Etiology of Urinary Obstruction.—Obstruction of the lower urinary tract is much more frequent in men than among women, the two chief causes

being stricture of the urethra and hypertrophy of the prostate, both being commonly associated with cystitis. Repeated overdistention of the bladder causes weakness of its muscular wall, and tends to destroy the tightness of the valve-like closure of the ureteric orifices; the germ-laden urine thus enters the ureters, and sooner or later infection follows; ascending infections are thus much more common among males. Attacks of cystitis, accompanied by frequent urination and violent contraction of the detrusor muscle, with associated spasm of the vesical sphincter, may, by greatly increasing the intravesical pressure, produce the same result. This latter method of infection takes place also in women. There are two other frequent causes of ascending infection of the kidney: they are stone in the pelvis or ureter and hydronephrotic distention of the kidney from any cause, notably from the intermittent distention of movable kidney (Israel). Infection may occur by the introduction of germs directly into the ureter by the ureteral catheter—such cases have been observed; they are, however, rare. Fistulous openings in the ureter communicating with the rectum, the vagina, and with the external integument, rarely with the interior of a uterus the seat of endometritis, are followed by ascending infection.

Diagnosis of Ascending Infections.—When a patient, who has not suffered from cystitis, develops pyuria with acid urine containing a small number of epithelial cells, and perhaps bacteria, and has pain and tenderness in the kidney region and along the course of the ureter, we may diagnosticate a pyelitis, though the cause may still be obscure; nor can we, for a time, eliminate a hematogenous infection of the kidney and the development of a kidney abscess, except by the absence of profound septic symptoms, and of the additional local signs accompanying such abscess formation. In searching for a causation we would think of stone, of tuberculosis, of movable kidney, of infected hydronephrosis, of pressure upon the ureter, etc., as already stated elsewhere, and each of these alternatives must be eliminated by suitable diagnostic methods. Cases of ascending pyelonephritis secondary to cystitis often run a severe and rapid course; the symptoms closely resemble the acute septic cases already described under Hematogenous Infections of the Kidney, nor is it always possible to differentiate clinically one from the other. We look for a cause in the lower urinary tract—stricture of the urethra, enlarged prostate, a gonorrhea, a tumor of the bladder, vesical calculus, cancer of the uterus or rectum, a kidney or ureteral sinus, a traumatism to the lower urinary tract, or a history of a hydronephrosis. The cystoscope and ureteral catheter, the X-rays, and a carefully taken previous history, bacteriological examination, and examination of the twenty-four hours' urine, are all important aids in the diagnosis.

PYONEPHROSIS

Some knowledge of the pathological anatomy and methods of development of the pyonephrotic kidney, in addition to the data already given, are desirable for an intelligent diagnosis of the condition. Two factors are necessary for

its production—obstruction in the lower genito-urinary tract and infection. Some of the conditions under which such obstruction may occur, and the manner in which infection may take place, have already been mentioned; a brief outline of the pathological changes produced is here given.

Size of the Tumor.—Only very rarely does the kidney reach so large a size in primary pyonephrosis as is the case with infected hydronephrosis, and, owing to early inflammatory adhesions, the pyonephrotic kidney soon becomes firmly fixed to the surrounding structures, and often remains hidden beneath the ribs, where it may be difficult to palpate. Hydronephrotic kidneys, on the other hand, usually descend and become readily palpable below the costal arch; not being confined by inflammatory adhesions, they remain more or less movable, and partly by the action of gravity, partly by growing in the direction of least resistance, they come to occupy a lower position than a pyonephrotic kidney.

Pathological Details.—Partly adapted from J. Israel, "Clinic of the Surgical Diseases of the Kidney."

Contents of the Pyonephrotic Sac.—The kidney may contain pus the character of which will vary according to its age and the variety of infection; it may be yellow and creamy, or green, or bloody; it may have a foul and putrid odor or none; the pus may be converted into a buttery or cheesy mass. If several cavities exist which do not communicate, each may contain a different material. Frequently phosphatic calculi are found, either in crumbly, puttylike masses, or as fine sand mixed with inspissated pus and granular detritus. A deposit of phosphates may occur in the wall of the sac in the form of a finely granular incrustation or in thin plates. Sometimes we find branching calculi, one limb in the pelvis, and others occupying the dilated calices. Or many calculi of varying sizes and shapes are found in the pelvis or in the loculi of the cortex; often these calculi are coal-black in color and have a smooth and glistening surface.

The Pelvis and Calices.—The mucous membrane of the pelvis and calices is sometimes smooth and atrophic, sometimes red, juicy, thickened and edematous. Its surface may be covered with papillary outgrowths, and a similar condition may be found throughout the ureter. The kidney substance is thinned, pale, and usually soft, pulpy, and easily torn, occasionally sclerosed and tough. In well-advanced cases the medullary substance is entirely destroyed by a combination of pressure and ulceration. Under the microscope the lesions of pyelonephritis, as already described, are observed. The cortex exhibits areas of granulation tissue and of yellow, miliary areas of fatty necrosis and minute abscesses, seldom large abscess cavities.

Perinephritis.—The *capsula propria* is often firmly adherent to the indurated fatty capsule. In some cases the cortex is perforated and a collection of pus forms between the cortex and the fibrous capsule, or in other cases this is perforated with a resultant perinephric abscess. The communication between such an abscess and the interior of the kidney is not always macroscopic.

Condition of the Cavities.—In true pyonephrosis the dilatation of the renal pelvis does not usually greatly exceed that of the calices. In this respect it differs from the condition ordinarily found in hydronephrosis, in which the pelvis is,

as a rule, largely dilated; on the contrary, the pelvis may be shrunken. The calices, on the other hand, may be dilated to such an extent that they form the largest portion of the tumor. The cavities in the parenchyma vary much in size,

FIG. 124*a*.—PYONEPHROTIC KIDNEY, CONTAINING LARGE PHOSPHATIC CALCULI, AS DEMONSTRATED BY X-RAYS, NEPHRECTOMY, MARCH, 1909. Patient had marked pyuria and had been treated for bladder trouble for several years. (Author's case.)

and the orifices leading from them to the renal pelvis are much more irregular than is the case in hydronephrosis. They may be large, small, or obliterated. In very advanced cases the renal parenchyma being nearly or quite destroyed, an abundant growth of rather firm fatty tissue may occur, taking the place of the parenchyma, filling the sinus of the organ, surrounding and growing between the calices so that the kidney is converted into a mass of firm fat, containing only a few small abscess cavities and a small central cleft—the renal pelvis.

The Ureter.—Ascending infection ending in pyonephrosis is always accompanied by chronic inflammatory thickening of the ureter; the tube may be converted into a dense hard cicatricial cord or much fat may be deposited in its walls. Firm adhesions occur between the ureter and surrounding structures, notably the peritoneum. Such a ureter may form a firm cord as large as a man's

thumb, readily palpated as it passes over the brim of the pelvis of a slender person, or felt as a firm mass *per vaginam* or *per rectum* as it enters the bladder. The caliber of the ureter will vary according to mechanical conditions. In those cases following combined urinary obstruction and infection the ureter will be thickened and dilated. If infection of the bladder has occurred without obstruction the caliber of the canal may be uniformly narrowed, or it may exhibit localized strictures. These appearances are quite different from those seen in hydronephrosis, where the changes in the ureter remain of a purely mechanical character until infection occurs. The ureter undergoes dilatation and at the same time its walls are thinned so that it may consist of a convoluted, relaxed, almost membranous canal of the size of the small intestine. When such a ureter becomes

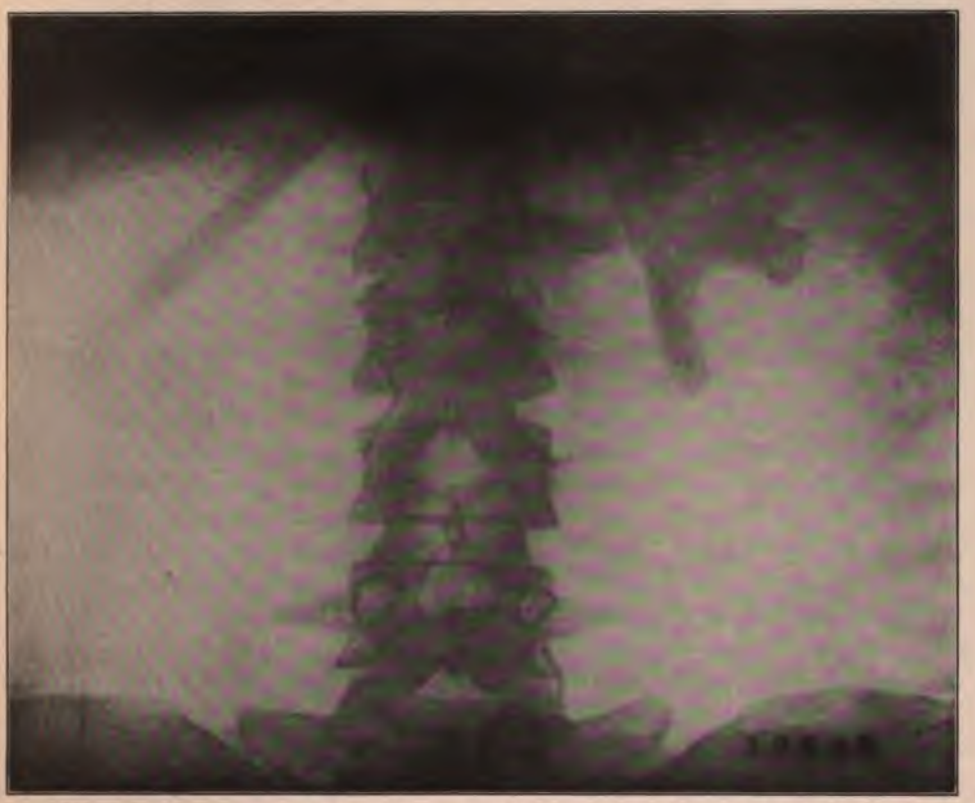

FIG. 124*b*.—X-RAY PICTURE OF LARGE PHOSPHATIC CALCULI IN THE KIDNEY, X-RAY BY DR. E. W. CALDWELL. (Author's case.)

infected the changes in its form consist in the formation of valvelike projections of its walls, together with kinks and bends due to adhesions. When a ureter, not previously subjected to distention, becomes infected, inflammatory infiltration leads to a cicatricial contraction, and thus to a diminution in length of the ureter such that, in certain cases, a cystoscopic examination will reveal a funnel-shaped depression surrounding the ureteric orifice, due to the traction of the shortened ureter upon the bladder wall.

The Arterial Supply of Pyonephrotic Kidney.—As the result of destruction of the renal parenchyma the renal artery often becomes much diminished in size. Obliterating endarteritis and cicatricial contraction of the inflamed tissues surrounding the renal pedicle are causative factors; thus one sees large old pyonephrotic kidneys supplied by an artery of very small size.

Etiology.—Primary pyonephrosis is caused, in the vast majority of cases, by infection ascending from the lower genito-urinary tract, and in most of these by infection from the bladder—cystitis. Other causes of ascending infection have already been mentioned. In order that pyonephrosis may develop, the infection must be accompanied by an obstructive lesion; in the absence of such, pyelitis and pyelonephritis occur, as already described, but not pyonephrotic distention. Such obstruction is furnished by inflammatory thickening of the ureter and the formation of stricture. This type of the disease is usually unilateral, and occurs in a previously healthy kidney. In the cases following stricture of the urethra, enlarged prostate, and other conditions where the kidney and ureter have already been subjected to aseptic distention, the disease is frequently bilateral; this form is more common among men, and, as already stated, is not often capable of relief by operations upon the kidney itself. In many cases by the time the pyonephrotic condition has commenced to give symptoms these patients have ceased to be suitable subjects for a surgical operation. The condition of the kidneys is often first recognized at autopsy.

The type most frequent in women is unilateral, because they rarely suffer from obstructive conditions affecting the bladder, and therefore both ureters, but suffer from many conditions from which men are exempt, affecting one ureter—movable kidney, scoliosis, pregnancy, prolapse of the uterus, pelvic tumors, and exudates. Thus the number of women operated upon for pyonephrosis exceeds the number of men. Inasmuch as the disease of the kidney occurs in men quite frequently as the result, direct or indirect, of gonorrhea, and in women as the result of pregnancy—the infection being caused in a fairly large proportion of cases by faulty catheterism—we find a large proportion of the cases occur during the third and fourth decades of life. As stated, infection of the kidney, the result of prostatic hypertrophy, is rarely operable. It is to be understood that we are now disregarding the cases of secondary pyonephrosis due to stone and tuberculosis. At the extremes of life the causes leading to primary ascending infections of the kidney are relatively rare.

Among the operations done upon the kidney in the New York Hospital during the past six years (1902–1908) there have been 28 cases of more or less typical pyonephrosis; 9 of these are cases of my own; the remaining 19 operations were done by other members of the attending surgical staff, who have kindly permitted me to use their material. Some data in regard to these 28 cases may be interesting: The sexes were equally divided—14 males and 14

females. The youngest patient was a boy, aged twelve; the oldest, a woman, aged fifty-three; the oldest male was forty-four; the youngest female was twenty-five; the average age of the males was thirty-six, of the females thirty-nine. Among the women all had been married; all but two had borne one or more children; one had never been pregnant. In all but one case the disease was unilateral. The list includes only cases operated upon.

The *mode of infection* could be determined among the males with a fair degree of accuracy. In 5 the infection was of the ascending type, and was ascribed in 3 to cystitis following gonorrhea, once with stricture of the urethra. One was an ascending pyogenic infection following the prolonged suprapubic drainage of a tuberculous bladder. One followed cystitis accompanied by vesical calculus. Five cases were evidently due to secondary infection following nephrolithiasis. Four were believed to be hematogenous infections of unknown origin. Among the females: One was due to a pyelonephritis coming on during the sixth month of pregnancy. One was probably an ascending infection due to cystitis, resulting from a vesico-vaginal fistula. One was an ascending infection from a cystitis of unknown causation. One was a hematogenous infection, the cause of which was obscure. Two were secondary to renal calculus. In the remaining cases the origin remained obscure.

In a number of the cases the *bacteriological data* were recorded: In several the pus from the kidney gave no cultures—these were the closed cases of pyonephrosis; in other cases cultures were obtained of Bacillus coli, Streptococcus pyogenes, and Staphylococcus pyogenes aureus; in several, cocci and bacilli were present, but were not identified.

In 27 cases *the urine* contained pus in varying amounts—in 1 (a completely closed sac) the urine contained no pus. In 3 cases the urine contained also a notable quantity of blood—these were all secondary to renal calculus. In nearly all the cases compensatory hypertrophy of the other kidney had occurred, so that the quantity, specific gravity, and daily output of urea was normal, or nearly so. In cases of doubt the cystoscope and ureteral catheterization gave valuable aid as to the site of the disease and condition of the opposite kidney. Several forms of intravesical separator were used; the results were, in general, much less satisfactory than those furnished by ureteral catheterization. The local signs and symptoms referable to the kidney and bladder and the general symptoms varied in different cases, as described at length in the text.

Upon the 28 patients *primary nephrectomy* was done in 18 cases, with 3 deaths—17.11 per cent; in 1 of the 3 the other kidney was the seat of an ascending pyelonephritis at the time of operation, and the removal of the pyonephrotic organ was, at best, but a forlorn hope. In 2 cases secondary nephrectomy was done, with no deaths. Thus in 20 nephrectomies there were 3 deaths, a mortality of 15 per cent. All of the 19 patients who recovered were, as far as known, restored to good health. In 9 cases nephrotomy was done —2 died; 5 were improved, but not cured. In 1, secondary nephrectomy was

done successfully later, with cure. Two only were recorded as cured as the result of incision of the kidney.

Symptoms and Diagnosis of Pyonephrosis.—In what has preceded, many of the signs and symptoms of pyonephrosis have incidentally been described. A brief recapitulation and some data in regard to differential diagnosis are here given. In those cases following cystitis there will be a history of pyuria, painful and frequent urination, etc., of variable duration, short in some cases; in others extending over a period of years. In those following an obstructive lesion—stricture of the urethra, enlarged prostate, a tumor of the bladder, vesical calculus—there will be a history of the signs and symptoms of these conditions. In those secondary to calculus in the renal pelvis or ureter there will be a more or less distinct and characteristic history of renal colic, hematuria, etc. (See Renal Calculus.) In those following catheterism, unclean instruments will have been used, or instruments will have been introduced into an infected bladder. (See also Etiology.) It is to be borne in mind that even in those cases due to a lesion—stone, stricture, or other—in the ureter or renal pelvis, or originating in the kidney itself, the symptoms of frequent and painful urination are often present, and may mislead an unwary surgeon. Many patients are treated for cystitis for long periods while the lesion is at a higher point. Thus in a case which came under my observation some years ago:

A lad, aged seventeen, had had two attacks of hematuria some years before I first saw him. The attacks were accompanied with and followed by painful and frequent urination, pain in the glans penis, and pyuria. A surgeon had opened his bladder through the perineum in search of stone; none was found. His symptoms continuing, his bladder was drained by the suprapubic route, without benefit. A few months before coming under my observation he began to have chills, fever and prostration, with marked pyuria, and rapidly lost flesh and strength. When seen he was thin and anemic. He complained of pain in the glans penis, frequent and painful urination and *ardor urinæ*. A large mass could be felt in the belly, extending from the right lumbar region as far down as the umbilicus and to the median line in front. The tumor was fairly movable, not tender; flat on percussion. Did not move on respiration, and was thus differentiated from the lower border of the liver which overrode it. Pressure on the tumor caused pain in the bladder and glans penis. Urine—specific gravity 1.010, acid, abundant pus, no tubercle bacilli.

Right Nephrectomy—Pathological Report.—Ureter much thickened, three quarters of an inch in diameter. Calices much dilated and filled with pus. Kidney much enlarged; made up of a number of abscess cavities containing thick, greenish-yellow pus. The walls of these cavities consisted of fibrous tissue; the shell was very thin in spots. Some of the abscesses did not connect with the pelvis. The patient survived. The pain and frequency disappeared at once after the operation. Two years later he was in fair health; he still had frequent urination on account of a contracted bladder, but no pain.

Pyuria.—The pyuria of pyonephrosis may be continuous or intermittent, or there may be none. When the ureter remains patent, pus will be contin-

ously present in the urine; when the ureter is closed from time to time the pyuria will, in absence of cystitis, be intermittent; when the ureter is permanently closed the urine may be free from pus. When pyuria is intermittent the symptoms are characteristic. When the urine ceases to be purulent, septic symptoms, pain, and sometimes tumor formation will appear; as the urine again becomes purulent these symptoms and signs will subside; the amount of pus discharged will be very large.

Constitutional Symptoms.—Symptoms of chronic sepsis are regularly present; they will vary in intensity in different cases, and in the same patient from time to time. In the sudden cases following unclean catheterism, and in those developing during pregnancy, the symptoms will be those of acute sepsis. In the more chronic forms the patient will have chills or chilly sensations from time to time, an evening rise of temperature, sweating, gradual loss of flesh and strength, loss of appetite, sometimes diarrhea; he will become anemic and acquire the peculiar yellowish pallor seen in chronic septic poisoning.

Tumor.—In well-developed cases it will usually be possible to feel a tumor in the loin, unless the patient is very fat, or unless, as sometimes happens, the kidney is very firmly adherent to the diaphragm. In these cases, as stated, the enlargements may, for the most part, occur in an upward direction and project but little into the abdomen. In other cases the mass may project far below the ribs—as low as the iliac crest, or even reach to Poupart's ligament. But very large cystic tumors of the kidney are apt to be originally hydronephrotic in character. The tumor will possess the characters already described as belonging to tumors of the kidney, but will be less movable than hydronephrotic cysts or even than malignant tumors during their early stages. There will rarely be anything characteristic about the consistence of the mass—it may feel hard or soft, it may or may not fluctuate. In some cases the tumor will, from time to time, vary in size, and the diminution in size will be accompanied by the discharge *per urethram* of a large amount of pus. In thin and flabby persons it will often be possible to palpate the thickened ureter. The condition of the other kidney must be determined by one or other of the means already described.

Pain.—There is nothing characteristic about the pain attending pyonephrosis. There may be severe pain at the beginning of the disease, of the renal colic type, and such attacks of pain may be repeated at intervals—from urinary obstruction and increased tension in the kidney. Between the attacks there may be no pain or only a sense of fullness or dragging in the abdomen. There will often, as stated, be frequent and painful urination, and pain in the glans penis or down the thighs. When the tumor has reached a large size it may cause discomfort and pain from pressure. Such patients incline the body toward the affected side, and may even lie with the thigh flexed upon the abdomen.

Tenderness over the distended kidney may be marked or absent. In some cases there will be tenderness both in front and behind, in others pressure in front may be painful, while pressure over the flank may give relief.

The Urine.—The distinctive characters of pyonephrotic urine are the presence of pus, sometimes of a little blood, and usually of bacteria. While the urine from a pyonephrotic kidney always contains pus, and usually in large amount, the quantity of pus passed *per urethram* is subject to wide variations, as already described. If the other kidney remains healthy, and has undergone compensatory hypertrophy, the daily quantity and the content of urea may be normal. If the other kidney is infected, or is the seat of diffuse nephritis, the quantity of urine will usually be diminished, the specific gravity and content of urea below normal. Unless the pyuria is very marked, it will be possible to discover casts, etc., in the urine. If an ammoniacal cystitis exists, or if, as rarely happens, an ammoniacal decomposition occurs in the pyonephrotic sac, the urine will contain masses of glairy gelatinous pus, triple-phosphatic crystals, bacteria, and will have an ammoniacal or putrid, foul odor. (See also Cystitis.) In these cases the diagnosis of pyonephrosis must be made largely on the physical signs and symptoms furnished by the enlarged kidney itself.

Differential Diagnosis.—*Infected Hydronephrosis.*—If a history can be obtained of a slowly growing painless tumor of the kidney region, or of intermittent polyuria, and if, then, a patient suddenly develops pain and moderate septic symptoms with pyuria, the diagnosis of infected hydronephrosis is probable. (See also Hydronephrosis.) In many instances a differential diagnosis will not be possible until the kidney is operated upon.

Perinephric Suppuration.—Perinephric abscess and pyonephrosis often coexist. Well-advanced perinephric abscess gives the signs of a localized or diffuse suppurative process in the loin, and septic symptoms of a more acute character than we commonly find in uncomplicated pyonephrosis; yet, in the absence of pyuria, we are unable to exclude pyonephrosis until the abscess is incised and the kidney examined. In either case operative treatment is demanded.

Tuberculosis of the Kidney.—The presence of other tuberculous lesions of the genito-urinary tract and the finding of tubercle bacilli in the urine are the surest aids in diagnosis. In many cases there will be a history of one or more attacks of hematuria. The tumor formed by a kidney previously healthy which becomes the seat of tuberculosis is rarely very large. It is to be borne in mind, however, that tuberculous kidneys frequently become the seat of secondary pyogenic infections. (See Tuberculosis of the Kidney.) Under these circumstances there may be developed a tuberculous pyonephrosis of large size, and a microscopical examination may be necessary to establish a diagnosis. In these cases the clinical picture and the macroscopic appearance of the kidney on section may be that of pyogenic infection merely. If, however, the primary infection was tuberculosis, a layer of tubercles containing giant cells and diffuse tubercle tissue will be found beyond the limit of the purulent inflammation. An infection of a hydronephrotic kidney or of a pyonephrotic kidney with tubercle bacilli is also possible, and in these cases, also, a large tumor may be formed.

Abscess of the Kidney.—An *abscess* of any origin or a *suppurating cyst* which ruptures into the bladder or ureter will give rise to a sudden discharge of much pus with the urine. From the history and physical examination of the abdomen it will usually be possible to exclude pyonephrosis. If the condition of the bladder renders it possible, cystoscopic examination may clear up the diagnosis by the discovery of an abnormal opening in the bladder wall.

Tumors of the Kidney.—From solid and other tumors of the kidney, the history and absence of pyuria will usually exclude pyonephrosis. Cystic degeneration of the kidney and carcinoma are commonly attended by hematuria. If a rapidly growing sarcoma of the kidney is undergoing degenerative changes, there may be very pronounced septic symptoms with turbid urine. Under the microscope, tumor cells in a state of fatty degeneration, or fragments of tumor tissue, may be discoverable.

As an example of a typical case of pyonephrosis originating probably from an ascending infection following parturition, possibly from an infection due to the presence of a calculus in the renal pelvis, I append the history of a woman upon whom I operated some years ago in Roosevelt Hospital:

The patient was forty years old, the mother of six children, the last child being three years old. Soon after the birth of this child she began to suffer from more or less constant pain in the right loin. The pain sometimes became much more severe, and during these attacks was felt along the course of the ureter. The attacks were sometimes accompanied by a chill and a febrile movement. It was also noted that her urine was constantly loaded with a white sediment. She had lost flesh and strength and was markedly anemic. The pain had continued up to the time I saw her. Examination of her abdomen revealed the presence of a firm, elongated, smooth, rounded, tender tumor, occupying the region of the left kidney, extending to the median line in front, and downward to within one inch of the umbilicus, not movable. The left ureter felt enlarged and tender. The patient had no fever, but her pulse was 104 and of poor quality. Urine, acid; specific gravity, 1.028, very turbid, heavy sediment, a large amount of albumin, and microscopically much pus, many colon bacilli. I kept the patient under observation for five weeks, attempting to improve her general health by food and tonics, her condition being so feeble that I feared to remove her kidney.

In the mean time she had several severe attacks of renal pain, during which the tumor in the loin increased in size and the amount of pus in the urine diminished. These attacks were accompanied by a rise of temperature and increased prostration; upon their subsidence it was noted that the urine was more purulent and that the tumor became smaller and less tense. The patient had no frequency of urination nor was there any symptom referable to the bladder. After a fortnight, Harris's segregator was introduced into her bladder, under cocain anesthesia, the bladder having been previously thoroughly washed. In twenty minutes two drachms of fairly clear urine had become collected from the right catheter, one and a half drachm of thick pus from the left. The pus was found to contain numerous colon bacilli but no tubercle bacilli. Two guinea pigs were inoculated with this pus, but failed to develop tuberculosis. The urine from the right catheter was

slightly turbid, contained a trace of albumin, a moderate number of pus and epithelial cells, no tubercle bacilli, but many colon bacilli. (The Harris instrument as well as other forms of intravesical urinary separators, are quite useless for bacteriological diagnosis.)

At the end of five weeks nephrectomy of left kidney. Incision below and parallel to the ribs. Fatty capsule, thick, firm and dense, adherent to *capsula propria*. Subcapsular enucleation of kidney and large portion of ureter. Ureter much thickened, an inch and a half in diameter. Kidney, ureter, and fatty capsule removed in one piece. Clamp left upon stump of ureter. Suture and drainage. Moderate shock. Kidney removed; measured five inches vertically, three and a half inches horizontally; its surface was smooth, firm, and lobulated, fluctuating in places. Section of the organ showed it to consist of a series of large abscess cavities with dense fibrous walls, each communicating with a greatly dilated calyx. The pelvis was moderately dilated, contained several ounces of thick pus and a black phosphatic calculus three quarters of an inch in its greatest diameter. No kidney tissue proper could be recognized by the naked eye. The microscope showed in places a thin layer of remaining kidney cortex in a state of chronic suppuration. The walls of the ureter were greatly thickened and infiltrated with pus. Its caliber was dilated to the size of a No. 30 French sound and was in a condition of chronic purulent inflammation. The mucous membrane was studded here and there with polypoid growths varying in size from that of the head of a pin to that of a dried pea. The patient regained her health completely.

CHAPTER XVI

TUBERCULOSIS OF THE KIDNEY

Tuberculous infection of the kidney may occur in several ways: (1) Embolic or hematogenous infection. (2) As an ascending infection from the bladder through the ureter. An ascending infection through the lymphatics is also theoretically possible. A third mode is possible—namely, direct extension of a tuberculous focus in the vicinity of the kidney; it is so rare as scarcely to deserve notice. Primary tuberculosis of the ureter is believed not to occur, at least there are no clinical evidences indicating it. From a surgical point of view the existence of miliary tubercles in the kidney, as a part of an acute general miliary tuberculosis, is of no interest; both organs are probably infected in all cases.

Occurrence of Primary Chronic Tuberculosis of the Kidney.—It was formerly believed that tuberculosis of the kidney was always, or nearly always, a secondary infection preceded by tuberculosis of other parts of the genito-urinary tract—the bladder, the prostate, seminal vesicles, and testes; this view has been upheld by eminent authorities, notably by Guyon. At the present time it is believed by most surgeons and pathologists that primary tuberculosis of the kidney by embolic infection is the rule; secondary or ascending infection the exception. By primary tuberculosis of the kidney we mean that the kidney is the first part of the genito-urinary tract to be attacked. In the majority of cases, doubtless, the disease of the kidney is secondary, in the sense that foci of the tuberculosis already exist in other parts of the body, the lungs, the joints, the bones, the bronchial or mesenteric glands, the mucous membrane of the alimentary tract or elsewhere, and that bacilli derived from such sources infect the kidney through the blood. After tuberculosis of the kidney has existed for a certain time the lower portions of the genito-urinary tract, the ureter, the bladder, the prostate, sometimes the urethra and seminal vesicles, often the other kidney, become involved. When this stage is reached the disease is usually hopeless from a surgical point of view. There is much ground, however, for the belief that in a large proportion of cases the kidney, and the kidney alone, is, in the beginning, the seat of the disease, and in the earlier stages of the process surgery offers a fair promise of complete *cure*.

One of the strongest arguments in favor of the occurrence of primary tuberculosis of the kidney, and of the limitation of the disease to this organ for a

considerable period, is to be gained from contemplating the results of nephrectomy in renal tuberculosis.

Thus, among 8 cases of nephrectomy for tuberculosis of the kidney done in the Roosevelt Hospital, in 2 the disease was bilateral, 1 of them died at once; the other died nearly a year later from anuria caused by closure of the ureter by a stone; a third died of phthisis; 6 survived. One was in good health sixteen years later. One was in fairly good health five years later. One was in good health four years later. One was in good health one year later. One was in fair general health one year later, but had a vesico-vaginal fistula—nontuberculous. One left the hospital with a good prospect of complete return to health. Among 9 nephrectomies done in the New York Hospital for renal tuberculosis, 7 were apparently cured; 2 died. Israel reported 13 cases of nephrectomy for renal tuberculosis in which the bladder was not involved: One died of shock; 1 of tuberculosis of the other kidney; 1 of acute general miliary tuberculosis; 10 were restored to health. In none of the 7 cases recorded as cured in the New York Hospital was there reason to believe that the patients had other foci of tuberculosis—either in the genito-urinary apparatus or elsewhere; and in none of the 9 operated on could an ascending infection be reasonably assumed.

Sex.—Women are more often infected with primary tuberculosis of the kidney than men—thus, of 19 cases in the New York and Roosevelt hospitals, 12 were women, 7 were men. Among 17 of Israel's cases of primary renal tuberculosis, 13 were men. While men often suffer from tuberculosis of the prostate, testes, and seminal vesicles in conjunction with or as the result of renal tuberculosis, women very rarely have tuberculosis of the kidney and of the tubes and ovaries as well.

Age.—The disease is most common during the third and fourth decades of life. In 9 Roosevelt Hospital cases the average age was twenty-four; the youngest patient was fourteen; the oldest thirty-five. In 10 New York Hospital cases the average age was thirty; the youngest was fifteen; the oldest forty-three.

Bilateral and Unilateral Renal Tuberculosis.—It is probable that in about 75 per cent of the cases but one kidney is infected at the beginning of the disease.

Involvement of the Bladder.—After the process has existed for a long time and the bladder is involved, the percentage of bilateral infections is notably higher. At the time of operation Israel found the bladder involved in 43.75 per cent of his cases. Vigneron found, in 23 autopsies upon operated cases of primary renal tuberculosis, the bladder diseased in 12, healthy in 11.

Pathological Anatomy of Primary Infections.—Embolic infection of the kidney with tuberculosis is followed by the formation of typical tuberculous nodules, over a larger or smaller area of the kidney, whose size and situation will vary with the size and position of the arterial branch in which the bacilli have found lodgment. Such an area may be small, and limited to one pole, or there

Fig. 1.—Tuberculosis of the Kidney; Cut Surface of the Organ, Showing Shape and Arrangement of the Tuberculous Areas in the Cortex. Caseation Occurred, but as Yet no Softening. (After Israel.)

Fig. 2.—Acute Pyelonephritis, Showing Numerous Miliary Abscesses in the Cortex of the Kidney. (After Israel.)

PLATE I

ay be several separate foci, or disseminated nodules may occur throughout the idney substance (a rapid and fatal form of the disease). The tuberculous nfiltration may occur in the form of a pyramidal infarct with its base at the apsula *propria* or surrounding the glomeruli (F. T. Brown); or in the pyramids, or at the apices of the pyramids (Willy Meyer). In the kidney, as elsewhere, the tubercles tend to coalesce, to break down, or to undergo caseous degeneration; there are thus formed cavities in the kidney substance, containing tuberculous pus or cheesy material, and lined by an ulcerated wall of tuberculous granulation tissue. The kidney may thus come to be riddled with irregularly shaped tuberculous abscesses. These finally rupture into the calices and pelvis, infect these—tuberculous inflammation of the ureter, and later of the bladder, follows. The condition is one of tuberculous pyonephrosis, with more or less extensive diffuse tuberculosis of the entire genito-urinary tract. In not a few instances secondary pyogenic infection is added to the tuberculosis, and the clinical picture, as well as the gross appearance of the kidney, may be such that the character of the original infection is only to be discovered by the microscope.

In purely tuberculous infections, perforation of the kidney capsule and the formation of a perirenal tuberculous abscess is less frequent than in ordinary pyogenic infection. The fatty capsule is usually thickened and sclerosed, and affords, in many cases, an efficient barrier to the spread of the disease, yet, in some cases, such rupture does occur with the production of a large tuberculous abscess (see clinical history of one of my cases.) A practical point of consequence is that infection of the perirenal structures may occur without actual perforation of the capsule—i. e., by infection through the lymphatics, so that one may find a tuberculous abscess in the loin without any apparent connection with the kidney; such an abscess may even heal after incision, the original focus in the kidney remaining. Nephrectomy will be necessary to effect a cure. When broken-down tuberculous material is discharged into the renal pelvis, plugging of the ureter is a common accident, and since some secreting substance still remains in nearly all tuberculous kidneys, the mixture of urine and pus accumulates and constitutes a tuberculous uronephrosis, or, if pyogenic infection follows, a tuberculous pyonephrosis, such kidneys may form a cystic tumor of large size. (See also Differential Diagnosis of Pyonephrosis.)

Tuffier described a form of tuberculosis of the kidney which he called *degenerescence massive du rein*; the condition occurs when the ureter is stopped or obliterated very early in the disease. The kidney becomes converted into a thin-walled, translucent sac containing a puttylike mass, or material resembling the contents of a dermoid cyst. Such a case occurred among the tuberculous kidneys operated on at Roosevelt Hospital. A tuberculous kidney was removed from a woman who died comatose on the tenth day. The other kidney was converted into a thin sac containing white pasty material. The ureter was obliterated. The kidney was smaller than normal.

The changes in the form and size of the kidney as the result of tuberculous infection vary greatly. In the early stages the kidney is but little if at all enlarged; as softening and the formation of cavities occur, the kidney is increased in size—uniformly if the process is diffuse, or if the infection be limited to one pole of the organ that alone may be enlarged. The subsequent enlargement depends upon whether or not the ureter remains patent; if not, large cystic tumors may be formed, as already described. The surface of the disorganized kidney may remain smooth, or distinct lobulation may occur as the result of the formation of separate abscess cavities.

Infection of the ureter is followed by ulceration of its mucous membrane, and later of its muscular coat, or by diffuse tubercular infiltration of the ureteric wall. Accompanying these changes the ureter becomes greatly thickened—often as large as a man's thumb and quite rigid; much fat is often deposited upon its outer coat. The caliber of the ureter tends to become narrowed rather than dilated; often strictures are formed, and above these dilatations may take place. Firm adhesions form between the ureter and surrounding structures, notably with the peritoneum.

Ascending Tuberculous Infection of the Kidney.—While ascending infection of the kidney is much less common than the hematogenous type, still it is known to occur. Primary tuberculosis of the bladder is probably rare, but one of the regular events in the later stages of renal tuberculosis is secondary infection of the bladder; the other kidney may then be involved by an ascending infection of the ureter; certain pathologists believe this to be the regular way in which the second kidney comes to be involved (Tuffier). Probably in many cases the second kidney is infected through the blood.

Pathology.—The pathology of the ascending infections of the kidney differs from that of primary infections in that the apices of the papillæ are first involved. If a case exhibits well-marked tubercular cystitis and ureteritis, and we find superficial lesions of the kidney pelvis with ulcerations of the papillæ, we may conclude that the lesion is of the ascending type; such a conclusion is only possible during the early stages of the disease; later on the two types cannot be differentiated. Formerly it was believed that in the presence of tuberculous epididymitis and orchitis, and tuberculosis of the prostate and seminal vesicles, the kidney, when infected, became so by superficial extension along the urinary channels. In many of these cases, however, the bladder remains healthy for long periods, and we are forced to the conclusion that the coincident involvement of the kidney and the testis, for example, is accidental, both organs having been infected through the blood.

Symptoms and Diagnosis of Primary Renal Tuberculosis.—In no surgical condition is an early diagnosis more important than in primary tuberculosis of the kidney. An early positive diagnosis is frequently difficult, even impossible, for four reasons: (1) The difficulty of finding and identifying tubercle bacilli in the urine. (2) The complete latency of the disease in many cases during its early stages. (3) The frequency with which the early symptoms are

referred to the bladder, leading to a false localization and diagnosis. (4) The protean character of the early symptoms when they are referred directly to the kidney—thus, renal colic and hematuria may usher in the tuberculous infection of the kidney, and lead to the probable diagnosis of renal calculus. In the later stages of the disease mixed infection still further obscures the diagnosis; though, at this time, the presence of a surgical lesion of the kidney can usually be established without much difficulty.

Disturbances of Urination.—*Frequency and polyuria* are two of the most constant phenomena of beginning renal tuberculosis. The patient finds himself obliged to rise at night to empty his bladder one or more times. The condition appears at first to be purely reflex, and is usually not very marked —twice the normal frequency is perhaps the average. Extremely painful and frequent urination points usually to infection of the bladder itself, and especially to the trigone and vesical neck, occasionally to involvement of the ureter, and yet, as elsewhere noted, cases do occur where no lesion of the bladder is present, the kidney alone being infected, and where intense bladder irritation is the chief symptom. This is a peculiarity of renal tuberculosis so marked as to deserve especial attention.

The symptoms of bladder irritation may exist for a long time, even for years, and yet the cystoscopic appearance of the bladder may be entirely negative. The ordinary treatment for such symptoms arising from ordinary cystitis or as the result of chronic gonorrhea—i. e., irrigations of the bladder with nitrate of silver, potassium-permanganate solutions, etc.—will, in the case of renal tuberculosis, only make the symptoms more marked, and this is true to a more noticeable degree when the bladder itself or the prostate are tuberculous. *The bad results of local treatment are highly suggestive of tuberculosis.* There is one other condition to be thought of in this connection—many cases of tabes dorsalis suffer from an irritable bladder with painful and frequent urination, as the result of instrumentation, they usually develop a mild cystitis. *In these cases the results of local treatment are, in my experience, nearly always unfavorable*; hence, one should look for syphilitic scars, test the knee jerks, and look for a pupil which responds to accommodation for distance, but not to light, and is contracted.

In some cases of kidney tuberculosis the patient has a constant uncomfortable sensation in the bladder or perineum, and what may be called precipitancy of urination—i. e., when the desire comes he must urinate at once. There may be some pain and discomfort at the end of urination in the prostatic urethra and glans penis, due to spasmodic closure of the vesical neck. In some cases pain will, for the most part, be absent, but the patient will suffer from occasional attacks of painful urination with straining and vesical tenesmus. The intolerance of the bladder may be more marked at the beginning of the disease than later. Even after the bladder is involved, great differences exist as to pain and frequency. Thus, in the presence of deep ulcerations of the bladder wall the patient may suffer but little, while in other cases, where the cystoscope

shows merely congestion or slight ulceration of the mouth of a ureter, or a few miliary tubercles in the mucous membrane of the trigone, the frequency, tenesmus, and pain may be excruciating. In some cases the pain and discomfort felt during urination will be referred to the kidney region and along the course of the ureter. Among the nineteen cases already quoted, disturbances of urination—i. e., frequency and pain—were present in sixteen and were early symptoms; absent or not complained of by the patient in three.

Changes in the Urine.—Polyuria is one of the most constant accompaniments of primary renal tuberculosis during its early stages. The increase may be slight or considerable. Its presence, as such, is not likely to attract attention unless the twenty-four hours' urine is measured. Thus, Sondern found in seventy-four cases of genito-urinary tuberculosis that the average excretion was 1,430 c.c.; the largest amount was 2,200 c.c. (other observers place the maximum figures as high as 4,000 c.c.); the smallest 720 c.c. The former was a tuberculous pyelonephritis, the latter a tuberculous lesion of the prostate and bladder. The polyuria is a suggestive symptom merely, since any irritative lesion of the kidney and its pelvis may be attended by a similar increase. A marked diminution in the daily excretion would lead to the suspicion that both kidneys were involved. Israel states, from his own experience, that polyuria is more marked when the bladder is the seat of tuberculosis.

Pyuria.—In the early stages of renal tuberculosis it is rare that the amount of pus in the urine is sufficient to attract the patient's attention before any other symptom. Upon microscopic examination, however, pus in greater or less quantity is almost uniformly present, though when the lesion is still entirely within the parenchyma of the organ the amount of pus may be very small. When a tuberculous abscess breaks into the pelvis there will, if the ureter remains patent, be the sudden discharge of a large amount of pus, and thereafter pyuria will usually be marked, in some cases throughout the course of the disease; in others, after the abscess has ruptured and drained itself, the urine will again, for a time, become nearly free from pus. When the ureter is plugged the urine may be quite free from pus until the obstruction is overcome. If, as occasionally happens, the lumen of the ureter is obliterated the urine may remain quite normal. (See Tuberculous Pyonephrosis, also Degenerescence Massive du Rein (Tuffier)). I have seen but one case in which tubercle bacilli were found in the urine and no pus; this was a very early tuberculosis of the cortex before softening had occurred, and with no lesions of the pelvis or ureter. The patient had no other apparent lesion; the bacilli reached the pelvis of the kidney presumably by filtration.

Albumin, Urea, Chlorides, Etc.—In the early stages a small amount of albumin is usually present, rarely more than 0.5 in 1,000. Later on the content of albumin will vary with the intensity of the accompanying nephritis, the quantity of pus and of blood. It presents nothing characteristic, and the same may be said of urea, the chlorides and other solids, since other destructive lesions of the kidney are attended by similar changes.

Fig. 1.

Fig 2.

FIG. 1.—EXTERNAL SURFACE OF A KIDNEY THE SEAT OF EARLY TUBERCULOSIS. THE SAME KIDNEY AS THAT SHOWN IN FIG. 1, PLATE I. (After Israel.)

FIG. 2.—PAPILLARY CANCER OF THE RENAL PELVIS. (After Israel.)

Blood.—Microscopic quantities of blood, at least, are present in nearly all ses of renal tuberculosis; if the pyuria is profuse and the amount of blood inute, the presence of the latter may be obscured. In a fair proportion of ses blood will be present in macroscopic quantity from time to time. Thus, mong the 19 cases, hematuria was so profuse in 2 as to cause marked anemia; was present at intervals in macroscopic quantities in 10; in microscopic uantities, only, in 3; absent in 4. As stated, in some cases an attack of narked hematuria may be the first symptom observed; such may last a day r two, cease, and not recur, except in microscopic quantities, or the bleeding may be nearly continuous for many days, or successive attacks may occur at irregular intervals. Thus, microscopic hematuria was observed by Israel in 4 out of 18 cases as an initial symptom; in all but 1 the hemorrhage was small in amount and of short duration; in 1 it lasted four weeks and reduced the patient to a condition of profound anemia; at operation the source of the bleeding was found to be ulceration of the renal papillæ. In the slighter cases the hematuria is probably merely a congestive phenomenon not due to a gross lesion of the kidney vessels. In the advanced cases of tuberculosis of the kidney, in which the bladder is not involved and ulcerated, marked hematuria is infrequent.

Casts.—In the majority of the cases casts will be present in the urine and their number and character may be an index of the severity of the lesion, though this is true to a less extent of tuberculosis than of ordinary pyogenic infections. In some cases but few casts will be found, and these chiefly of the hyalin type. According to Sondern, this is apt to be the case when the foci in the kidney and pelvis are small and where only a few small broken-down areas are discharging into the pelvis.

Bacteriology.—The identification of the tubercle bacillus in the urine, together with the absence of tuberculous lesions of the lower genito-urinary tract, establishes the diagnosis of renal tuberculosis. With perfect technic and repeated examinations of numerous specimens it is possible, at the present time, to find the bacillus in a fairly large proportion of cases. Up to a quite recent date this has scarcely been true, and it is true to-day only under the most favorable conditions—i. e., in the hands of a highly skilled pathologist who has the opportunity to examine many specimens from each case. Thus, in the nineteen cases, tubercle bacilli were found in four only, though in every case repeated examinations were made. Israel states that in ten cases, where the lesion was confined to the kidney, a positive result was obtained in two. In the cases where the bladder also was involved the results were positive in eight out of thirteen cases—i. e., in 61.5 per cent.

The difficulties attending the detection of tubercle bacilli in urine are several: In early kidney lesions, before the evacuation of a softened area into the pelvis, there may be no bacilli in the urine. The bacilli, if present, may be few in number, even though the kidney lesion may be far advanced. The ureter may be closed or obliterated. They may be confounded with another

quite harmless germ—the smegma bacillus. In giving the following tion of the technic of examining urinary sediment for tubercle bacilli quoted largely from Sondern ("Genito-urinary Tuberculosis in the Laboratory," *Journal of Cutaneous and Genito-urinary Diseases*, July, 1900). Dr. Sondern informs me that a more extended experience has not caused a material modification of the views expressed in that paper.

First, as to errors arising from confounding the smegma bacillus with the bacillus tuberculosis. The smegma bacillus is frequently found upon the genitals, more often in females than in males. "Grünbaum examined fifty specimens of urine from forty-seven individuals; the sediments obtained by centrifuge were spread on covers and stained with carbol-fuchsin. He found no smegma bacilli in the specimens from males, but found them in fifty-nine per cent of the specimens from females. He found no smegma bacilli in urine obtained by catheter from eleven individuals, including both sexes. Bunge and Trautenroth have not only found smegma bacilli about the genitals, but also on the surface of the body, in the nose and mouth, and in other cavities lined with mucous membrane; in the deep urethra in one out of twelve specimens, and almost constantly in the anterior urethra of healthy males; between the labia in twenty-eight out of thirty healthy women, usually in the vagina, occasionally in the urethra. Specimens of urine drawn by catheter from the bladder were all negative." Sondern's personal experience with over 6,000 specimens of urine stains with carbol-fuchsin allows the conclusion that more than forty per cent of these presented smegma bacilli. . . . "In 270 specimens of separately collected kidney urine, all of which were obtained by the ureter catheter, excepting a few by the Harris segregator, organisms believed to be smegma bacilli were observed in a few instances." Sondern concludes "that urine obtained by catheter from the bladder should have the same care in differential staining as those voluntarily voided."

Smegma bacilli present wide variations in size and form—so much so that Sondern believes "it is but reasonable to question if all these are really one species of organism. True, they all show the same staining qualities, but other organisms rich in fatty matter may do this; and they do vary greatly in the time required to decolorize them by the various methods. Thus it is that only certain varieties of smegma bacilli resemble tubercle bacilli in outline. . . .

"Smegma bacilli may occur in clumps or singly. When in clumps the arrangement is usually an irregular one such as seen in a Widal clump reaction in typhoid cultures; but I have never found them in the characteristic grouping of tubercle bacilli." This grouping Sondern considers an important differential point, as well as the fact that "many tubercle bacilli suitably stained present a *beaded appearance or vacuoles, a condition never seen in the smegma bacillus.*"

Tubercle bacilli found in urinary sediments, when properly stained, occur singly at times; but in the large majority of cases in smaller or larger groups. The grouping is generally characteristic—the bacilli lie side by side parallel, and end to end in a more or less regular arrangement; the whole group is usually curved, as, for example, the whole or a part of the letter S.

Differential Staining.—The following method of differential staining is the one recommended by Sondern:

Staining with carbol-fuchsin, decolorization with nitric acid and subsequently with absolute alcohol, is the method which I have found most useful, though by no means free from objections. The specimens should be dried preferably on slides instead of cover-glasses, and fixed with heat, but *overheating must be carefully avoided, because this no doubt increases the power of resistance of smegma bacilli toward the decolorizing agents.* The slides are then stained in the usual way with carbol-fuchsin and heat for five minutes; here again overheating must be avoided for the same reason; the stain should steam slightly, but not boil. A small water bath constructed for the purpose has been found very useful in my laboratory. The excess stain is then washed off with water and the specimen well decolorized with 1 to 6 solution of nitric acid. On microscopic examination everything except the bacilli should have lost color completely. A few of the best groups of bacilli are selected and "ringed" by a substage or nose-piece arrangement, of which there are a number in the market; so that the same groups of bacilli can easily be found again. Then the specimen is immersed in absolute alcohol for further decolorization. While it is a well-established fact that smegma bacilli are decolorized by absolute alcohol much more quickly than tubercle bacilli, the objectionable feature of the method is that no definite time for this immersion can be stated in which the smegma bacilli will be completely decolorized, with at the same time no action on the color of the tubercle bacilli. While Miller states that the specimen should remain in the absolute alcohol for at least five minutes, I have not found this nearly long enough. Ewing advises the use of ninety-five-per-cent alcohol for eight to twelve hours, which is much more satisfactory. After considerable experimental work, I find that in the large majority of specimens, provided the sediment was obtained from an acid urine, an immersion in absolute alcohol from five to eight hours will completely decolorize the smegma bacilli without materially affecting the color of tubercle bacilli; in fact, the latter have frequently withstood the action of absolute alcohol for twelve hours. Smegma bacilli decolorize much more quickly in some specimens than in others. Tubercle bacilli in different specimens also vary as to their ability to withstand the decolorizing effect of absolute alcohol. Why this should be so seems difficult to explain, except that the reaction of the specimen of urine from which the sediment was obtained does exert an influence. Stained tubercle bacilli in alkaline specimens, and particularly if an ammoniacal fermentation is present, possess less resistance to alcohol than those of acid specimens. Bunge has also called attention to this point in his article.

Animal Inoculation.—Sediments of urine containing tubercle bacilli, when inoculated into guinea pigs, lead to the development of tuberculosis and death. The autopsy usually presents typical pictures which establish the diagnosis beyond a doubt. This method, *if combined with the proper precautions,* is certainly a valuable one. It at times happens, however, that the animals die as the result of other toxic or bacteric infections, and if enlarged mesenteric glands only are found, a tuberculous infection must not be assumed until a microscopic examination of these glands reveals a tuberculous lesion. On several occasions I have had inoculations of doubtful tuberculous urine made, and the animals died without, however, presenting typical post-mortem pictures of tuberculosis. . . .

Culture Methods.—The usual culture methods employed for the growth of tubercle bacilli in scientific research are not applicable for the purpose of diagnosis

of these bacilli in urine, because their growth is very slow and is buried under the relatively rapid growth of contaminating organisms present in every specimen of urine. Purdy advises cultures in gelatin and subsequent inoculation, but does not detail his method of doing away with the contaminating organisms.

W. Hesse, in the latter part of 1899, announced a new method for the rapid growth of tubercle bacilli which promises to be an important aid in diagnosis, and I believe in their differentiation from smegma bacilli as well. The culture medium is made up as follows:

Nährstoff-Heyden	5.0
Sodium chlorid	5.0
Glycerin	30.0
Agar-agar	10.0
Normal solution of soda crystals 28.6:100	5.0

This medium is used for plate cultures which after the inoculation are kept in the incubator at a temperature of 37° C. According to Hesse's article, he worked chiefly with sputum, and found evidences of growth of the tubercle bacilli in five to six hours, and decided colonies in from twenty-four to forty-eight hours. The contaminating organisms are retarded in their growth. . . . Since the early part of December, 1899, I have applied the method to almost every specimen of urine sent to me for examination, which might possibly contain tubercle bacilli or which presented tubercle bacilli or smegma bacilli on microscopic examination, and for the present have arrived at the following conclusions: As yet the culture method has never revealed tubercle bacilli in specimens in which the same were not found by some other method of examination, including animal inoculation. In a moderate number of specimens the rapid growth of contaminating organisms ruined the culture attempt. Numerous specimens were encountered, however, in which the usual microscopic examination revealed a few bacilli not always characteristic, while the Hesse culture method produced pictures justifying an undoubted diagnosis of tuberculosis. All attempts, and they were numerous, to grow smegma bacilli from urine and from smegma obtained from both male and female resulted negatively. If the above conclusions are found to hold good after more extensive trial, the method will certainly be of value in the differentiation between tubercle and smegma bacilli, and will furnish a more suitable product for animal inoculation.

Additional.—Urinary sediments intended for staining for tubercle bacilli should preferably be obtained by centrifuge, because this not only permits examining the specimen as fresh as possible, but also usually results in the presence of larger numbers of organisms. When the sediment of pus is very thick and profuse, and the bacilli found in very small numbers, it is well to employ the Biedert or the v. Sehlen method, which will result in the presence of larger numbers of bacilli, but makes differentiation of tubercle and smegma bacilli more difficult, as it disturbs the characteristic grouping and affects to a certain extent the ability on the part of tubercle bacilli to retain the stain while immersed in the absolute alcohol.

Bacteria Other than Tubercle Bacilli.—Tuberculous urine shows the ordinary forms of nonpathogenic organisms usually found in urine, and in the presence of ammoniacal cystitis or of mixed pyogenic infection may show a

great variety of pathogenic cocci and bacilli. (See Pyonephrosis.) There is, however, one noteworthy peculiarity about tuberculous urine—i. e., it does not undergo an acid nor an alkaline fermentation as readily as normal urine when exposed.

Epithelial Cells.—The epithelial cells found in tuberculous urine have the same diagnostic significance and no more than has already been stated under Pyonephrosis.

Crystalline and Other Deposits.—Uric-acid crystals are frequently present in the acid urine of tuberculosis but not in sufficient number to suggest the presence of renal calculus. In the presence of ammoniacal fermentation triple phosphates will be present as in other cases of ammoniacal cystitis.

Résumé of Sondern's Plan for the Examination of Urine in which Tubercle Bacilli may be Present

Urinary Sediment to be Stained for Tubercle Bacilli.—Sediment obtained by centrifuge; if thick and purulent, prior use of Biedert or v. Sehlen method when necessary.

If not sufficient albumin, add a small amount of dissolved egg albumin.

Sediment dried on microscopic slides at room temperature under cover.

Fixed by heat, carefully avoiding overheating for reasons stated.

Stained with carbol-fuchsin and heat, again avoiding overheating.

Washed in water and thoroughly decolorized with nitric acid (1 to 6).

Examined with microscope and several good groups of bacilli "ringed."

Immersed in absolute alcohol for five to eight hours, which almost always decolorizes smegma bacilli.

If in doubt use Hesse culture method.

If desired, the colonies thus obtained may be inoculated into guinea pigs and enlarged lymph nodes present on post-mortem examination looked over for characteristic tuberculous lesions.

Renal Tuberculosis with Degenerative Changes in the Tuberculous Deposits. These Abscesses Communicating with the Renal Pelvis.—These are the specimens of urine which are most frequently received for analysis. They present the typical picture of a tuberculous pyelonephritis, and are the ones in which tubercle bacilli are most readily found. Owing to the associated and more or less pronounced cystitis, with at times alkaline fermentation, the specimens resemble those from like lesions due to other causes, and mistaking smegma bacilli for tubercle bacilli in the latter is the most frequent cause of an erroneous diagnosis of tuberculous pyelonephritis.

A typical specimen from a case of tuberculous pyelonephritis of this class presents the following picture: More or less polyuria, lowered specific gravity, an acid reaction, rather pale color, a not offensive odor, an amount of albumin corresponding to the degree of renal involvement in addition to what the pus, etc., would account for, possibly traces of acetone, daily amount of solids, particularly urea, depending on the degree to which the parenchyma is involved, and a more or less profuse sediment, showing no tendency to coagulation; on microscopic ex-

amination, almost invariably a small amount of blood, more or less pus, according to the degree of pyelitis and the number of tuberculous abscesses, usually fe casts only, irrespective of the extent to which the parenchyma is involved, a epithelial cells referable to the renal pelvis. In addition there are elements more or less cystitis, but usually these are insignificant as compared to the ma lesion. It is only in exceptional and usually advanced cases that the evidences chronic cystitis are decided, and an ammoniacal fermentation results. Tubercl bacilli are usually easily found, and if there is no decomposition they are witho difficulty differentiated from smegma bacilli by appropriate methods. If the cystitis is not decided, it is strange how long the specimen may stand at room temperature before decomposition occurs.

A vital question remains—to what extent does the usual analysis justify an opinion as to the involvement of one or both kidneys? If the specimen presents evidences of decided tuberculous degeneration of the kidney and the daily excretion of solids, particularly urea, remains perfectly normal, it may be reasonable to infer that *possibly* the other kidney is not affected and is doing the excretory work for both. A more definite conclusion is, I believe, not prudent, and absolute information on this point must be left to the cystoscopic examination and the analysis of separately collected urines obtained by ureter catheter, for those collected with the Harris segregator seem unreliable for this purpose, as the horns of the instrument may detach tuberculous masses from the walls of the bladder, which might be looked upon as being of renal origin.

Vesical Tuberculosis Alone, or Associated with a Tuberculous Lesion of the Prostate, Seminal Vesicles, etc.—To judge by the specimens received, the former condition is very rare, the latter more frequent, but usually they seem to be the result of a primary renal lesion. When existing alone the only characteristic features found in the urine are tubercle bacilli, with usually an acid reaction, the specimens otherwise resembling those found in lesions of the same organs due to other causes.

Subjective Symptoms Referable to the Kidney Region.—Only in exceptional cases is primary tuberculosis of the kidney attended in its early stages by pain in the loin and along the course of the ureter; as stated, in a few cases pain in these regions may be felt during urination. In the cases attended by marked hematuria typical attacks of renal colic may accompany the hemorrhage, probably by blocking of the ureter by clots. It is to be borne in mind that sharp attacks of renal pain may occur without hemorrhage or the presence of any other foreign body or cause of obstruction in the urinary passages, the explanation being, as in the invasion of the kidney by pyogenic germs, a sudden congestion of the kidney and an increase in intracapsular tension.

Thus, in 2 of the 9 Roosevelt Hospital cases, attacks of renal colic and marked hematuria ushered in the disease and were repeated at intervals later. In 7 cases the patients sooner or later developed moderate pain or a severe discomfort in the loin. In 6 there was tenderness on pressure over the affected kidney; in 3 there was none. Among the 10 New York Hospital cases all but 1 had symptoms of bladder irritation; in none of them was

a history of renal colic obtained. The sensations referred to the kidney region were either a dull pain, a sense of pressure, or of fullness; in several, the attention of the patient was first called to the kidney region by objectively finding a palpable mass in the abdomen. In 2, large perinephric abscesses developed, the patients complained merely of a moderate soreness over the kidney. In the cases of pyogenic secondary infection of a tuberculous kidney the symptoms are those of pyonephrosis already described.

Formation of a Palpable Tumor.—As already stated, the kidney is not markedly enlarged in renal tuberculosis affecting a previously healthy kidney until the disease is well advanced, and then the tumor formed is rarely more than double the size of a normal kidney. Unless some special reason exists, such as great thickness of the abdominal wall from fat or a perinephric abscess, such kidneys can usually be successfully palpated. In case the upper pole of the kidney merely is the seat of the disease no palpable enlargement is likely to be recognized. A distinct enlargement of the kidney was recognized in 6 of the 9 Roosevelt Hospital cases. (See also Tuberculous Pyonephrosis.)

Influence on the General Health.—Patients with renal tuberculosis suffer from notable disturbances of the general health. A certain proportion of them suffer from an evening or nocturnal rise of temperature, sometimes preceded by chilly feelings and often followed by cold sweats. In other cases attacks of fever of a variable duration and intensity will occur from time to time, the patients being free from fever in the interval. Patients with a combination of renal and vesical tuberculosis are more apt to have febrile symptoms than those who have renal or bladder tuberculosis alone. Presumably the tuberculous ulcers in the bladder form a good absorbing surface for the poisonous matters descending with the urine from the kidney.

Anemia.—Marked anemia is regularly developed in the course of the disease and may reach a point where the hemoglobin is diminished to fifty per cent or less.

Digestive Disturbances.—Digestive disturbances are common—loss of appetite, indigestion, sometimes diarrhea. Accompanying these symptoms, emaciation, lassitude, and muscular weakness are regularly developed.

The Diagnosis of Renal Tuberculosis.—As may be gathered from what has preceded, the clinical picture of renal tuberculosis is a very varied one. The condition may readily be confounded with a variety of lesions of the kidney, notably with renal calculus, and here even the X-rays do not permit a differentiation, since secondary stone formation is by no means rare in tuberculous kidneys; further, with ordinary pyogenic infections of the kidney and with kidney tumors, and in case the kidney is movable, the symptoms may be referred, for a time at least, to that condition. In some cases the formation of a secondary perinephric abscess will, if the ureter is closed, lead to error, as already described—i. e., the urine may be clear and the connection between the abscess and the kidney not evident. There is nothing characteristic about renal pain, renal hematuria, or the formation of a renal tumor; pyuria is

present under many conditions and, indeed, it must be said that a positive diagnosis is in many cases impossible before operation; fortunately many of the conditions with which we are likely to confound renal tuberculosis demand at least an operative exploration of the kidney.

From a diagnostic point of view we may divide the cases into two groups: (1) Those in which the presence of tuberculosis is certain. (2) Those in which it is probable merely.

1. Cases in Which the Presence of Tuberculosis is Certain.—In the first group belong the cases where tubercle bacilli are found in the urine, or where, though no bacilli are found, tuberculous lesions of the papilla of the ureter or of the trigone are characteristic as seen through the cystoscope. In the first instance, if the lower genito-urinary tract is intact, the bacilli must come from the kidney. In the second, in the presence of unilateral enlargement of the kidney or of definite symptoms referable to one kidney, we may conclude almost positively that a descending infection from the kidney has caused a secondary tuberculosis of the ureteric papilla, or the trigonum, or both. The papilla of the ureter may be simply congested, swollen and edematous, or ulcerated, or the trigonum may be studded with small, sharply circumscribed, intensely congested spots. In cases of widespread tuberculosis of the bladder the conditions are not so simple; the affection of the kidney may be an ascending or hematogenous infection with pyogenic organisms. A case of this kind came under my care in the New York Hospital a few years ago. The patient was a physician, aged forty-three, who had suffered from a diffuse tuberculous cystitis for many years. He had a permanent suprapubic opening in his bladder to relieve the agonizing tenesmus from which he suffered. The urine was ammoniacal and contained much pus, from which cultures of Streptococcus pyogenes were obtained, as well as other forms. He developed a tumor in the kidney region and septic symptoms. Upon removing the kidney it was found to be a pyonephrotic kidney of moderate size. The lesions were those of an intense pyelonephritis, with no sign of tubercle. Streptococcus pyogenes in pure culture was obtained from its interior. The patient survived the nephrectomy, though still very miserable from the condition of his bladder.

Diagnostic Difficulties in Diffuse Bladder Tuberculosis.—In cases of diffuse bladder tuberculosis satisfactory cystoscopy is usually impossible; these bladders rarely admit of proper distention, the field is soon obscured by pus and blood. The mere effort to distend such a bladder for cystoscopic examination is often attended by active hemorrhage. It is rare that the ureter catheter can be passed, and, if passed, that uncontaminated urine can be obtained.

The Other Kidney.—The mixed urines cannot give positive assurance of the soundness of the second kidney (see quotation from Sondern). With an intact bladder in the presence of a closed tuberculous pyonephrosis the urine represents the product of the other kidney merely; hence, a definite conclusion is possible, assuming that the cystoscopic picture and inability to pass a ureter catheter demonstrate that but one kidney is delivering urine to the bladder.

Under other conditions the sole means of diagnosis to be relied upon is the collection of the separate urines through the ureteral catheters. Personally, I have little confidence in the results obtained by intravesical separators in tuberculosis; certainly no reliance is to be placed upon bacteriology of urine so obtained. A prejudice exists in the minds of some English, German and American surgeons against the use of a ureteral catheter on the side of the supposedly sound kidney. They fear the danger of infecting the sound kidney. Although a few instances of such infection are recorded, they are very few, and among them are cases where, it appears to me, the facts do not justify the conclusions drawn. Certainly ureteral catheterization is an invaluable diagnostic measure, and the results amply justify the procedure in cases of doubt as to the condition of the second kidney. This, I believe, voices the opinion of the majority of American surgeons whose experience in this field has been large. (For details of the procedure, see section on "Cystoscopy" and "The Urine in Genito-urinary Tuberculosis.")

"*Cystoscopy in Tuberculosis of the Urinary Tract*," Willy Meyer (*N. Y. Med. Jour.*, April 27, 1907). The following in regard to "Chromocystoscopy" is quoted from the above article:

To force the entrance into a ureter with an ulcerated mouth is unwise and rarely indicated; the mere fact *that it is ulcerated* proves the respective kidney to be the original seat of the disease. In most cases belonging to this class ureteral catheterization is superfluous so long as the mouth on the opposite side is seen to be healthy, and urinary analysis of a twenty-four hours' specimen has shown a sufficient excretion of urea. Only in patients in whom the latter is below the normal minimum, attempts at catheterizing both sides, then necessarily in conjunction with cryoscopy, seem indicated.

This procedure can be obviated if an intramuscular injection of indigo-carmin be given before starting the cystoscopic examination. The latter method (*chromocystoscopy*), introduced by F. Völcker, of Heidelberg, three years ago, has proved a great aid in many of these cases, as well as in cystoscopy in general. The dark-blue colored, rhythmic ejaculations of urine, as seen coming from the healthy side about five to ten minutes after the injection, are in marked contrast to the scanty, light-blue secretion of the affected kidney, which appears later (ten to fifteen minutes), and, besides, is often seen to be mixed with pus and cheesy material; now and then the spurts do not show any coloring at all. Völcker has established the fact that a tuberculous kidney is unable to produce a concentrated urine even in the incipient stage of the disease. Thus chromocystoscopy in descending tuberculosis of the urinary tract in many instances enables us to avoid catheterism of the ureters with cryoscopy. The health or disease, as well as the functional capacity of either side, can in this way be determined in a remarkably simplified manner. It is obvious that colored emissions of urine will likewise greatly assist us in locating and distinguishing the ureteral openings in an ulcerated bladder.

2. Cases in Which the Diagnosis of Tuberculosis is Probable Merely.—We shall consider first those cases in which the lesion is confined to the

kidney. In such cases the patients will come to us complaining usually of frequent and painful urination; polyuria will be more or less marked; cystoscopic examination will show a normal bladder; the conclusion may then be drawn that the kidney is at fault. In a few of these cases the injection of tuberculin may establish the diagnosis, in many it will fail. The method is not very widely used upon human beings in America. When it succeeds the injection will be followed by a febrile reaction. In some cases it has been followed by pain in the kidney, by an increase in the size of the kidney, localized tenderness, hematuria, and the appearance of tubercle bacilli in the urine, thus establishing the diagnosis. I have no personal experience with the use of tuberculin in renal tuberculosis, but when we consider that a positive reaction sufficient for a diagnosis practically means an acute exacerbation of the disease, and that at best the results are uncertain, perhaps dangerous, it is not to be wondered at that the method has found but little favor among surgeons. Not every surgeon is in a position to use the cystoscope or to have it used upon his patients. What, then, should make him suspect that an apparently simple case of cystitis is really disease of the kidney? I quote a pregnant sentence from Israel: "The first and most important foundation stone of a correct diagnosis will be laid if, when we find a catarrh of the bladder, the causation of which is not entirely clear and which fails to respond to ordinarily successful methods of treatment, we seriously consider whether we have not to do with disease of the kidney."

Several conditions require at once to be eliminated: chronic gonorrhea of the posterior urethra; vesical calculus; prostatic hypertrophy; locomotor ataxia or other cord lesion; irritability of the posterior urethra following excessive masturbation in males, sometimes accompanied by a mild catarrhal inflammation of the vesical neck; an occupation neurosis of the bladder, not uncommon among locomotive engineers from long-continued vibration; in females, inflammatory conditions of the uterus and its adnexa; in fact, all the common causes of frequent and painful urination. It is true that some of these conditions are not necessarily accompanied by pyuria, but the pyuria of early renal tuberculosis may be very slight; in one case already mentioned it was absent. All these conditions, and indeed others, should be sought for. The patient's family and personal history should be carefully inquired into, especially with reference to tuberculous disease. The patient should be stripped naked and search made for ancient tuberculous scars, notably in the neck; evidences of former bone or joint trouble should be sought for, sometimes a slight kyphos, which a patient may strive to hide through vanity, representing a tuberculous process in the vertebræ, perhaps recovered from in childhood. The physical examination of the thorax should be carefully made, especially at the apices; a shallow thorax, imperfect lung expansion, retraction of the supraclavicular fossæ, a pale, dead white skin, combined with notable hairiness of the body, together with other general physical characters known to predispose to tuberculous infection, should be sought for. The kidneys should be palpated in every instance of apparent cystitis; if a tumor or tenderness be found the surgeon's attention is attracted

at once to the probable seat of the trouble, and if, in addition, the patient has a history of progressive loss of flesh and strength, of an evening rise of temperature, and night sweats, together with the characters of the urine, as already described, the diagnosis of renal tuberculosis is very probable. In the cases exhibiting kidney colic or renal pain combined with hematuria, the kidney will, of course, be fixed upon as the seat of disease, and it will remain to establish its tubercular character, not always an easy or possible task.

Cases with Other Foci of Tuberculosis in the Genito-urinary Tract.—The examination will include search for nodules in the epididymis, the prostate, and the seminal vesicles. The lower end of the ureter may sometimes be felt enlarged or thickened through the vagina or rectum. Early invasion of the bladder can best be discovered by the cystoscope, as already described.

General Observations.—In young males gonorrhea is by far the most frequent cause of cystitis, combined with pyuria, and painful, frequent urination; one of the difficulties in excluding tuberculosis in these cases lies in the fact that tuberculous invasion of the prostate, seminal vesicles, testicles, and bladder is often secondary to gonorrhea. In general, the constitutional dyscrasia following renal tuberculosis is out of proportion to the apparent gravity of the local lesion; thus a moderate pyuria combined with symptoms of bladder irritation, and due to causes other than tuberculosis, is *not* attended by progressive loss of flesh and strength, by occasional attacks of fever, by night sweats, by anemia, and other positive signs of some serious constitutional disorder. In these cases, failing to find bacilli in the urine, we must wait—studying the urine frequently, and examining the bladder with the cystoscope from time to time, until, sooner or later, either the bacilli are discovered, or some local signs or symptoms, such as have been detailed, will permit us, at least, to fix upon the kidney as the seat of the trouble. In practice we find that we operate upon many kidneys where the diagnosis remains doubtful as between renal calculus, tuberculosis, and pyogenic infection; the last secondary, oftentimes, to one or other of the former lesions; and as stated, the microscopic examination of the specimen must sometimes be called to our aid before a final answer is reached.

I append short histories of 5 cases of primary renal tuberculosis operated upon by me within the last few years, all of which appear to have resulted in cure, although 3 of them were most unpromising at the time of operation. In no one of them was the bladder seriously involved; in but 1 of them were tubercle bacilli found in the urine. Three were women, 2 were men. In all a primary renal tuberculosis by hematogenous infection seemed certain.

Case I was a married woman, aged thirty-four, who had suffered from frequent and painful urination with pyuria for four years. There was a history pointing to gonorrheal infection, and upon this basis her supposed cystitis had been treated, without improvement, at intervals since the commencement of her symptoms. She had gradually deteriorated in general health, had lost flesh, become

anemic and feeble. Some months before I saw her she had commenced to have dull pain and tenderness in the region of the right kidney. She had consulted another surgeon, who had incised the kidney and evacuated pus. This wound had failed to close. The patient had become moderately septic, the wound continued to discharge pus, the urine continued purulent, and from time to time was said to have been bloody. When she came under my care the conditions were as described. The painful and frequent urination had continued; the urine, however, was practically normal, containing only a little pus. Cystoscopic examination showed but slight congestion of the bladder with notable edema and redness of the right ureteral orifice. No urine could be seen coming from the right ureteral orifice, nor could a catheter be inserted; a catheter passed into the left ureter collected normal urine. The patient was suffering from a moderate chronic sepsis. The right kidney was enlarged, distinctly palpable, moderately tender, and immovably fixed by the scar tissue of her former operation. The kidney was removed and found to be in an advanced stage of tuberculous pyonephrosis, to which had been added a pyogenic infection. The ureter was impervious. The patient recovered, her wound healed, her bladder ceased to give symptoms, and she has since regained good health.

CASE II.—A female, single, aged thirty-two, who had suffered from frequent and painful urination for two months. She was a slender, delicate-looking young woman, who had lost flesh and strength for a number of weeks. She had occasional chilly sensations in the evening and a slight febrile movement every night. She had moderate polyuria, her urine contained a moderate number of pus cells, but no blood, otherwise normal. No tubercle bacilli found. Cystoscopic examination of bladder negative. Her right kidney was enlarged, readily palpable, and moderately tender.

Nephrectomy (Right Kidney).—On section, kidney showed densely grouped miliary and submiliary tubercles throughout the parenchyma, over areas 0.5 to 1 cm. in diameter. Near the center of the kidney was an area of caseation measuring $3 \times 1 \times 1$ cm. The renal pelvis and calices were dilated, their walls thickened and lined by a soft grayish tissue. The ureter was dilated and thickened.

Microscopical Diagnosis.—Rather early tuberculous pyelonephritis. The patient survived and regained her health completely. When last seen by me, two years after the operation, she was in good health and had no symptoms referable to her urinary apparatus.

CASE III.—A man aged thirty-four. No venereal disease. Private coachman by occupation. For past three years thinks he has not been as robust as formerly. He has no cough. For more than a year he has had moderate soreness in the right lumbar region. For the past nine months he has steadily been losing flesh and strength and has had night sweats. He has never had any sharp pain in the region of the kidney, ureter, testis, or glans penis. Has never had frequent or painful urination. Has never passed blood. Has noticed that his urine has been cloudy for several months. Sputum and stools negative for tubercle bacilli. *Urine* contained a moderate amount of pus and a few blood cells. Tubercle bacilli found on one occasion in urine after many trials; otherwise normal in quantity, specific gravity, and content of urea. The patient looks like a previously strong and vigorous man who now suffers from some profoundly depressing constitutional disease

He is emaciated, feeble, and depressed. His appetite is lost. He has attacks of diarrhea. He had an evening rise of temperature to 101° to 102° F. and a cold sweat nearly every night. Examination of his abdomen shows a distinct fullness of the right flank extending downward as far as the crest of the ileum in front. There is tenderness and rigidity of the abdominal wall of that side, with a diffused sense of resistance, but no tumor can be definitely outlined on account of the rigid contraction of the muscles.

Diagnosis.—Tuberculosis of right kidney with tuberculous perirenal abscess, ureter probably nearly impervious. Patient had consulted a very eminent medical practitioner, who had made a similar diagnosis and advised against surgical interference. Accordingly I removed his right kidney. Upon making a cut parallel to the ribs a large perirenal tuberculous abscess was opened which extended below into the right iliac fossa, and required a subsequent oblique incision at right angles to the first to drain it. The kidney was found in a dense, thickened, fatty capsule, firmly adherent to surrounding structures. It was removed with some difficulty, together with as much of the thickened ureter as I could reach. Curettage of the large tuberculous abscess cavity, which seemed to reach nearly to the bottom of the pelvis. Partial closure of the very large wound, gauze packing, and drainage. Shock marked, requiring active stimulation and infusion, from which patient slowly recovered.

Pathological Report (Specimen).—The right kidney measures $10 \times 5 \times 3$ cm., and 12 cm. of ureter, has a diameter of $\frac{3}{4}$ cm. in its lower two thirds and $1\frac{1}{4}$ cm. in its upper one third. Capsule strips easily, leaving a rough surface and a few distinct cicatrices. Outline of pyramids and markings of cortex are obscured. There are two large cavities near the surface, each about $3\frac{1}{2}$ cm. in diameter, one having a smooth wall like a retention cyst, the other a roughened and partly caseous wall. Miliary and slightly larger tubercles are numerous throughout the cortical and pyramidal portions. The lumena of the pelvis and ureter are enlarged, their walls are thickened, and they contain many miliary tubercles. Scrapings show large numbers of tubercle bacilli. There is some ulceration of the pelvis, but none at the points of section of the ureter, the tubercles here being in the submucous coat; the lowest end of the tube was the part examined. There are areas of chronic interstitial inflammation in the kidney. In many respects the lesion appears to be a comparatively recent and active one.

The patient survived the operation, but the very large wound closed down but slowly. After several months a second operation was done to afford better drainage for the large cavity which extended into the pelvis. It was thought that the stump of the ureter might be the cause of the tardy healing; careful search failed to find any sinus which seemed to lead to the base of the bladder. The whole wall of the rather large wound was curetted, after which the wound slowly healed down to a sinus, which remained open a good many months, but finally healed after a sojourn in the country. In the mean time the patient's general health had become good. Four years after the operation he was in perfect health, weighed nearly two hundred pounds, and was leading an active life. His urine is clear and normal. He has no bladder or other urinary symptoms. In December, 1908, six years after operation, he was in robust health.

The case is instructive in that it was rather unfavorable for a radical operation, and yet the outcome was, in the end, satisfactory.

Case IV was a man, forty-four years of age, who entered the hospital in August, 1906. There was no history of venereal disease. Four years before, he had commenced to suffer from frequent and painful urination. His urine had become purulent. He had not passed blood. He had not suffered from pain at that time referred to the region of the kidney. He had slowly but steadily lost flesh and strength. During the four weeks preceding he had continuous dull pain in the left lumbar region. His urine had been at times very cloudy and at other short intervals quite clear. Two weeks before, he had first noticed a swelling in the left flank which had become red and tender. He had lost much flesh and become very weak. Upon physical examination he was seen to be emaciated and profoundly anemic. Hemoglobin forty per cent. There was a large fluctuating swelling in the left flank, moderately tender, extending well down below the umbilicus and from the outer border of the quadratus lumborum muscle nearly to the median line in front. The patient had a daily evening rise of temperature and looked very ill indeed. His urine contained much pus, but no tubercle bacilli were found. The abscess was incised and was found to communicate with the kidney. Owing to the very feeble condition of the patient and the very dense adhesions surrounding the kidney it was thought best not to attempt to remove the kidney at that time. A portion of the kidney was removed merely of sufficient size for pathological examination. It proved to be the seat of tuberculosis. The patient's general condition improved greatly, and two months later he was able to leave the hospital in fair general health but with a tuberculous sinus leading to the kidney. He refused to have his kidney removed at this time. Six months later he reëntered the hospital with another abscess and in bad general condition. The abscess was incised; he again improved, but returned six weeks later to have his kidney taken out. This was done by an incision below and parallel to the ribs. The removal of the kidney was difficult on account of the dense adhesions. After this operation he made a good recovery. His wound healed. His general health improved and his urine ceased to contain pus. The kidney showed advanced tuberculous lesions. His general health is good one year and six months after the last operation.

Fig. 125.—Advanced Tuberculosis of the Kidney, Showing Numerous Tuberculous Cavities. I operated upon this patient in September, 1908. His symptoms were almost entirely referred to the bladder, which was also the seat of tuberculous infection, not, however, of a very extensive character. During the three months following the operation the man gained forty pounds in weight. His frequent and painful urination was at that time gradually improving.

CASE V was a woman, thirty-two years of age, who was admitted to the hospital September 9, 1907. One year before, she had commenced to have continuous pain in the right lumbar region. Her urine had become purulent. From time to time she had had attacks of pain referred to the right loin. No tubercle bacilli had been found in her urine. She had lost much flesh and strength and had become markedly anemic. The cystoscopic examination of the bladder showed the bladder wall congested. The orifice of the right ureter was red and swollen. Purulent urine could be seen escaping from it. Catheters could not be introduced. The left ureter opening appeared normal. The patient's general condition was poor. She was feeble and anemic and had a daily evening rise of temperature with occasional sweating at night. The right loin was occupied by a large, elongated, tender tumor extending downward as far as the navel and upward beneath the ribs. The tumor was fixed. The colon lay to its outside but crossed it in front. The right kidney was removed by an incision below and parallel to the ribs. The tumor was found to consist in its lower half of a large pyonephrotic kidney showing the lesions of an ancient tuberculosis upon which had been ingrafted a secondary pyogenic infection. The kidney measured $12 \times 7 \times 8$ cm. The upper half of the tumor consisted of a large abscess lying between the diaphragm and the kidney. The kidney was removed and the abscess evacuated; its walls were scrubbed with masses of sterile gauze. The patient made a very good convalescence and the very large wound healed for the most part *per primam*. She rapidly gained flesh and strength. Her urine ceased to be purulent. At the present time, January 1, 1909, fifteen months after the operation, her health is excellent. General condition has so improved that I recognized her with difficulty.

CHAPTER XVII

PERIRENAL INFLAMMATIONS

(*Perinephritis—Paranephritis or Perinephric Abscess*)

While the designation *perinephritis* may properly be used to signify inflammation of the *capsula propria* of the kidney and *paranephritis* to indicate inflammations of the fatty capsule and surrounding retroperitoneal loose connective tissues, yet *perinephritis* and *perinephric abscess* have been so long and so generally in use to signify the latter condition, that we prefer to retain them. Some surgeons prefer to use the term *perinephritis* to include merely inflammations of the capsules of the kidney, whether of the *capsula propria* or fatty capsule, both layers being usually involved; and to use the term *paranephritis* to indicate inflammation of the retroperitoneal fat in the vicinity of the kidney.

ETIOLOGY

Infection of the perirenal fatty tissues may be caused in a variety of ways. It may originate from suppurative lesions of the kidney itself, by perforation of a kidney abscess, or pyonephrosis; or without gross perforation, by extension through the lymphatics or blood-vessels of the kidney to the fatty capsule; since it has been shown that both the vascular and lymphatic channels of the kidney anastomose very freely with those of its inclosing fatty envelope. It has been proven beyond doubt that in bacterial diseases of all kinds the kidneys are one of the principal avenues through which the microbes are eliminated. Thus it is known that in scarlatina the urine is contagious. Typhoid bacilli have been repeatedly found in the urine not only during the disease, but months after recovery. The same is true, as already stated under Pyogenic Infections of the Kidney, of a great variety of pyogenic organisms. There is, moreover, great probability that pyogenic germs may cause no gross lesion in the kidney itself, but upon leaving the kidney through lymphatic channels may cause perirenal suppuration. Thus it is that a considerable number of perirenal abscesses follow infectious diseases—typhoid fever, diphtheria, any of the acute exanthemata, as well as localized suppurative lesions in distant parts of the body—furunculosis, carbuncle, paronychia, osteomyelitis, etc. Probably in the majority of these cases there is an actual lesion in the kidney, since in a good many pus and blood cells in small or moderate number may be discovered in the urine; but the lesion of the kidney need not be so severe

as to eventuate in suppuration of that organ. Perirenal suppuration may also arise from any pyogenic infection of the abdominal organs or abdominal lymphatics, either by extension through continuity of tissue or through the lymphatic channels. From abscesses or infections of the uterus, tubes, and ovaries of females, and of the prostate in males, the bladder, the testes, the seminal vesicles and vasa deferentia. Further, by lymphatic extension from infected lesions of the lower extremities. From suppurative lesions of the liver and biliary passages. From appendicitis—by direct extension, or through the lymph channels. From ulceration or suppuration of the stomach, the duodenum, and flexures of the colon. From perforation of the intestinal wall by foreign bodies swallowed and present in the intestine. (See Foreign Bodies in the Alimentary Canal.) In cases of chronic constipation with great distention of the colon it is believed that bacteria may pass through the wall of the distended and thinned gut, thus infecting the surrounding structures. In many instances of perirenal suppuration, on account of the intimate relations of the kidneys to the diaphragm, the pleura becomes infected; and the opposite route is also possible—suppurative pleuritis may be complicated by subphrenic or perirenal abscess. As the result of open wounds in the loin direct infection of the perirenal fat is, of course, possible. As the result of subcutaneous injuries, slight ruptures of the kidney with extravasation of blood, and perhaps a little urine, are not infrequently followed by a phlegmon around the kidney, the infection occurring probably as the result of the escape of pyogenic microbes from the vessels of the kidney itself. Severe lacerations of the kidney with the extravasation of large amounts of blood and urine into the perirenal tissues quite regularly suppurate, and are accompanied by the local necrotic phenomena and the profound intoxication of urinary extravasation seen elsewhere. In some cases of subcutaneous injury to the loin, though the kidney be uninjured, it is probable that a contusion of the colon, with sufficient diminution of the vitality to permit the escape through its coats of Bacillus coli or other pyogenic germ, may account for the occurrence of abscess. A certain number of cases of perirenal suppuration have been observed as the result of muscular strain; and in a few cases exposure to cold and wet have been cited as a cause—for want of a better explanation—the condition being parallel to the cases of acute osteomyelitis following such exposure.

VARIETIES OF PERINEPHRITIS

Three forms of perinephritis, each involving the fatty capsule, are ordinarily described. The first two are not necessarily attended by suppuration without the kidney; they arise from lesions of the kidney itself. The third is the lesion ordinarily described as perinephric abscess; it may arise from within the kidney or from any of the extraneous sources mentioned.

First Form—Sclerosing Perinephritis.—The fatty capsule becomes converted into a dense, firm mass of connective tissue surrounding the kidney, the con-

dition has already been mentioned under Pyonephrosis and Renal Tuberculosis. It also frequently results in cases of nephrolithiasis, and is, doubtless, to a great extent a protective process—an attempt on the part of nature to inclose the infectious material within the kidney. The practical importance of the condition is that a considerable tumor may be formed containing perhaps only the remnants of a disorganized kidney; and, further, that the removal of such kidneys is not always easy on account of the firm adhesion of the hardened capsule to the surrounding structures, notably to peritoneum, vena cava, diaphragm, etc. In case the adhesions are very dense I never hesitate to open the peritoneum widely over the tumor, protecting the viscera with abundant pads; one can thus enucleate the kidney more easily, and, I believe, with the least possible risk. A very careful dissection of the pedicle under the control of the eye is thus possible. If necessary the kidney may be removed first, and then its capsule; the peritoneum is then closed by sutures. I have never seen serious peritonitis follow the procedure, though the wounds have often been soiled.

Second Form—Lipomatous Perinephritis.—The condition consists of an increased production of fat in the capsule, which may be diffuse or circumscribed—i. e., limited to one or both poles, or to the vicinity of the hilum. The fat may entirely surround the kidney in a thick layer, and be prolonged upon the ureter, even to the bottom of the pelvis, and may form a considerable tumor. The lesion is always an irritative one, due to an inflammation within the kidney itself, and is more often due to stone than to any other cause. I have seen such lipomata which appeared to be a combination of a dense cicatricial perinephritis with much fat; they have surrounded a pyonephrotic sac in which no trace of kidney structure could be discovered, and always contained one or more stones. The extirpation of such kidneys is by no means easy, and involves, as in the preceding form, unusual difficulties in exposing and controlling the pedicle. Israel called attention to the fact that when such a lipoma is developed in the hilum of the organ the center of the mass almost always incloses a stone, or that a calculus lies just below it. The occurrence of these lipomatous masses is of diagnostic importance, since they are readily mistaken on palpation for kidney tumors, and, moreover, their presence may lead to an unnecessary and dangerous operation, since they are sometimes found to contain merely the innocent remains of a completely disintegrated kidney and a stone or two. A long history of disease of the kidney, together with the prolonged presence of the tumor and absence of symptoms, might possibly lead a very wise surgeon to refrain from operating upon such a case.

Third Form—Perirenal Suppuration (Perinephric Abscess, Perinephritic Abscess, Suppurative Paranephritis).—Of much greater diagnostic interest than either of the above lesions is that form of perinephritis accompanied by the formation of pus. The causation of such suppuration has already been discussed. It is to be borne in mind that not every phlegmonous inflammation in the loin is a true perinephric abscess; in many instances of infection from

sources other than the kidney itself, the abscess or phlegmon occurs in the retroperitoneal fat and connective tissues, the fatty capsule of the kidney remaining intact. Yet, for diagnostic purposes, it is well to group all the cases of retroperitoneal suppuration in the loin together, since in many, even after operation, the exact origin remains obscure. It is certain that by far the largest proportion of them originate in the kidney.

Pathological Anatomy.—Perirenal suppuration may occur in one of three situations: (1) Between the *capsula propria* and the kidney itself—a rare occurrence, which presupposes adhesion between the proper kidney capsule and the fatty capsule, and inflammatory infiltration of the latter. The pus may then lie between the kidney and these agglutinated layers; in rare cases such an abscess perforates into the retroperitoneal tissue. (2) Suppuration of the fatty capsule of the kidney. (3) Suppuration of the retroperitoneal fatty tissue in the kidney region, secondary to infection of the kidney or its fatty capsule, or due to a wound, or to the spread of infection from a distant focus, whether by direct extension or by lymphatic absorption.

2. *Suppuration of the Fatty Capsule Proper of the Kidney.*—Suppuration of the fatty capsule proper of the kidney may involve the entire mass of fat surrounding the kidney, and this has been accompanied in a small number of cases by necrosis of the entire organ. More commonly but a portion of the capsule is involved; most often the posterior part—i. e., that part lying behind the kidney, between it and the abdominal wall; less commonly by the capsule covering either pole; and least often the portion lying in front of the kidney.

According to the portion of capsule involved the abscess tends to spread and increase in size in one of several directions. When the posterior portion is the seat of suppuration the abscess forms a tumor in the loin with the kidney in front of and above it, and tends to perforate the abdominal parietes posteriorly between the last rib and the crest of the ilium. The common points being, first, just below the twelfth rib, near the outer border of the latissimus dorsi, and in front of the outer border of the quadratus lumborum. Second, just above the crest of the ilium in Petit's triangle. After reaching the subcutaneous tissues the abscess spreads superficially beneath the skin of the back, so that two pus sacs are formed, connected by a narrow opening in the muscular wall of the belly. In some cases the muscular layers of the back are extensively infiltrated before actual perforation occurs. In these cases edema of the skin of the loin and slight redness may be noticed before fluctuation is present, together with a resistant boggy condition of the entire loin. If the pus contains much blood the skin may be tinged brown, yellow, or light mahogany color, from imbibition of blood pigment.

When the fat at the upper pole is involved the pus tends to accumulate beneath the diaphragm on the left side; beneath the liver on the right, or in some cases a subphrenic abscess is produced on that side also. The diaphragm itself is often invaded, and thus a collection of pus may form between the diaphragm and the diaphragmatic pleura. Adhesions may then form to the lung,

and perforation into the lung with evacuation of the abscess through the bronchi—a cure is possible in this way in rare cases. More commonly septic pneumonia, or extensive destruction of lung tissue causes a fatal issue. In other cases the pleura is invaded without gross perforation, leading to a fibrinous exudate, a serofibrinous exudate, or a purulent exudate in the pleural sac (empyema). (See also Subphrenic Abscess.)

When the lower pole is involved the abscess tends rather to spread downward along the sheath of the psoas muscle, and may appear below—above Poupart's ligament, or even reach the bottom of the pelvis, or appear on the buttock through the sciatic notch. A characteristic lumbar lordosis with flexion of the thigh on the pelvis will then be produced; sometimes a scoliosis; sometimes merely rigidity of the lumbar spine. When, as rarely happens, the anterior portion of the capsule is involved (more often from pressure ulceration and perforation of the renal pelvis by a large calculus than from other causes), the abscess tends to present more to the front, crowding the kidney backward, or backward and upward. Often when opening these abscesses, notably the last two types, the kidney will be so displaced upward that it is very difficult to palpate satisfactorily, and usually remains quite out of sight. In any of the forms described perforation into the hollow viscera of the belly is possible, most often into one of the flexures of the colon; rarely into the stomach, the urinary bladder, ureter, vagina, rectum. While these accidents are all rather rare, perforation into the thorax and lung is by no means uncommon. Rupture into the peritoneal cavity is possible, though rare.

Symptoms and Course of the Disease—Diagnosis.—The perinephric abscesses secondary to suppurative lesions of the kidney itself will have been preceded by symptoms referable to the kidney, of a more or less marked character and by changes in the urine, unless the ureter is closed; another group, by some acute infectious disease; another, by a wound or injury to the loin, etc.; another, by a septic condition elsewhere in the abdomen. The general symptoms will vary a good deal, according to the virulence of the bacteria and to the various local and general precedent conditions, as described under Causation and Pathological Anatomy.

The *general symptoms* are those of a more or less acute sepsis. In some cases all the symptoms of acute septic intoxication will be present—a chill, a rise of temperature, an accelerated pulse-rate, sweating, nausea, and vomiting are prominent symptoms at the beginning of an attack, an increased leucocyte count, with relative increase of the polymorphonuclear cells and prostration. Obstinate constipation is common as the result of pressure upon the colon. If a previous disease of the kidney, a contusion or wound in the loin, a kidney sinus, or some other localized process in the vicinity of the kidney has been present, the surgeon's attention will be called to the kidney region at once; though it may be by no means easy to say whether the inflammatory process has originated within or around the organ. In other acute cases, where the previous history throws no light on the origin and nature of the process,

perinephric suppuration has often been mistaken for pneumonia, pleurisy, and notably for typhoid fever. In other cases the development of perirenal suppuration is slow and insidious; septic symptoms may be slight or unrecognized for weeks, and the condition may be mistaken for a number of other lesions—for neuralgia, for disease of the vertebræ, or even of the hip-joint.

When a tumor in the loin has been recognized, accompanied by pain and tenderness in that region and septic symptoms with changes in the urine, the main question for decision will be: Is the disease confined to the kidney itself or is it perirenal? If when first seen the abscess has already perforated the muscular wall of the belly at the common site, as described (namely, above the crest of the ilium or just below the last rib), the ordinary signs presented by subcutaneous purulent fluid collections will be present—fluctuation, tenderness, pain, edema, and moderate redness of the skin. The aspirating needle will establish the diagnosis of abscess at once, and may give valuable hints as to its origin. In cases of rupture of the kidney with extravasation the pus will usually be mixed with blood and urine, and a urinous odor will often be unmistakable, and the same may be true of other conditions in which the abscess communicates with the interior of the kidney. In other cases a fecal odor will indicate infection with Bacillus coli, but will give no hint as to the origin of the process. The mere presence of blood in the pus is not diagnostic of a renal rupture, since any retroperitoneal abscess may, and often does, contain a good deal of blood.

Differential Diagnosis.—When seen at an earlier stage, or when the abscess has not become superficial or has taken some other route in its extension, a differentiation from a mere enlargement of the kidney is often possible, and will depend upon the following data:

A perinephric abscess which has already infiltrated the abdominal wall usually exhibits superficial tenderness, whereas an inflammatory tumor of the kidney usually exhibits tenderness only on fairly deep pressure. The tenderness of perinephric abscess is most marked posteriorly just below the last rib; the tenderness of renal suppuration is usually most marked in front; yet the absence of tenderness will not exclude the presence of abscess in every case, since, in the more chronic forms, the abscess may take weeks to develop, and until the infiltration involves the muscles of the loin tenderness may have a diffuse or indefinite localization, or may be slight or absent. A kidney enlarged by an inflammatory process in its interior has a rounded or oval and sharply marked contour, and in many instances exhibits respiratory mobility or the sign known as *ballottement*—i. e., bimanual palpation—one hand on the abdomen the other in the loin—permits us to feel some passive mobility of the mass between the two hands—i. e., when the hand in the loin is quickly and forcibly lifted the kidney may be felt to rise and strike the abdominal hand. A perirenal abscess is immobile under all conditions, and its boundaries are less sharply defined, the resistance fading away gradually as the limits of

the inflammatory infiltration are approached. This is notably true of those abscesses which follow the psoas sheath downward; in these another sign is often present—fixation of the lumbar spine, sometimes with lordosis, often with scoliosis—concave toward the affected side, therewith flexion of the thigh upon the pelvis, all other motions of the hip-joint, except extension, remaining free and painless, or relatively so, thus excluding disease of the hip-joint.

The distinction between disease of the spinal vertebræ and perirenal suppuration may sometimes be made from the following data: Acute osteomyelitis of the spinal vertebræ is exceedingly rare, and is accompanied by tenderness over the affected vertebra, this sign being absent in perirenal abscess. Tuberculous disease of the vertebræ is much slower in development than perinephric abscess, is not attended by septic symptoms, and is after a time accompanied by a kyphos. Tenderness over the affected vertebræ is present. A very important point in the diagnosis is the presence of changes in the urine, not necessarily very marked. Repeated examinations of the centrifuged urine should be made, pus and blood cells and casts should be sought for, and, if found, especially if the patient at the beginning of the attack has had pain in the loin, radiating downward along the ureter, and if nausea and vomiting have been repeated upon successive days, the renal origin of the process is exceedingly probable.

If disease is upon the right side the local signs of appendicitis should be sought for and carefully excluded. It should be borne in mind that subphrenic abscess, suppuration of retroperitoneal lymph nodes in the vicinity of the kidney, together with phlegmonous inflammation of the retroperitoneal fat of the loin, and abscess of the liver, are by no means rare complications of suppurative, gangrenous, and perforative appendicitis.

In the cases seen at a time when no palpable mass in the loin is discoverable, the existence of pain in that region will lead to examination of the thorax. In some cases it will be noticed that the ribs move less during respiration upon that side; slight lateral bulging of the ribs may also be present. Auscultation may reveal a dry pleurisy, or effusion into the pleura, usually of limited extent, and the severity of the illness, together with the absence of expectoration and marked cough, will lead to the conclusion that the affection of the pleura is probably a secondary process. The introduction of an aspirating needle between the last two ribs may then clear up the diagnosis by showing the presence of pus. (For further details, see Diagnosis of Subphrenic Abscess.)

The modern methods—Widal's reaction, etc.—should permit the surgeon to exclude typhoid fever after a week or more. In all cases a disturbance in the leucocyte count, more or less marked, will be a valuable aid in confirming or excluding a suppurative lesion. In those cases of perirenal suppuration not directly connected with the kidney, a history of a precedent focus of suppuration somewhere in the body, even though small in size, should be sought

for, and may give a valuable hint. The genital apparatus of males and females, the rectum, and the lower extremities, should be examined as possible sources of infection. There will remain cases, notably those developing slowly and without much pain or marked septic symptoms, which will puzzle even careful surgeons for weeks, and where no diagnosis will be made until a palpable mass is discovered and incised.

CHAPTER XVIII

NEPHROLITHIASIS, RENAL CALCULUS, KIDNEY STONE

ACCORDING to their occurrence, we may divide renal calculi into two groups: Primary, when the stone is formed in a previously healthy kidney; and secondary, when the stone formation occurs as a result of disease already existent in the organ.

From the diagnostic point of view the primary calculi are of greater interest.

In the second class the disease of the organ itself usually forms the foreground of the picture, in which the signs and symptoms due to the presence of stone are more or less completely lost to view, except in those cases in which the stone causes temporary or permanent obstruction to the passage of fluids from the ureter to the bladder.

In their chemical composition kidney stones may be classed in several groups. Commonly, uric acid and oxalate of lime stones are grouped together.

The stones, consisting chiefly of alkalies and the salts of the alkaline earths, form a second group.

The cystin, xanthin, and indigo stones form a third.

This grouping is more or less artificial, inasmuch as stones consisting of a single ingredient are quite rare, and we usually find that several ingredients are mixed in varying proportions. The mixture may be, and usually is, an intimate one; or, on the other hand, the different ingredients may be arranged more or less regularly in concentric layers, each layer consisting of a single ingredient or of several ingredients. This mixture is found in the majority of primary as well as of secondary calculi.

The designation of stones as stones of calcium oxalate or stones of uric acid, for example, usually indicates merely that this or that ingredient predominates. Stones of nearly chemically pure oxalate of lime, uric acid, cystin, or other ingredient are occasionally found, it is true, but their occurrence is the exception rather than the rule.

Henry Morris gives the following figures, derived from 73 published cases, in regard to the relative frequency of occurrence of different types of kidney stones:

Calcium oxalate	44	per cent.
Uric acid	22	per cent.
Phosphatic	16.8	per cent.
Mixed	14	per cent.
Calcium carbonate and Cystin		rare.

James Israel, among 49 cases of primary renal calculi in his own practice, found 21 stones of phosphates and carbonates; 10 uric acid and uric-acid salts; 16 oxalates. Uric acid and urates constituted 20.4 per cent; 1 xanthin; 1 sulphur.

A careful perusal, however, of the case histories published in Professor Israel's work shows that a chemical analysis was made of the stones removed in most of his cases, and that the stones containing uric acid and urates alone without oxalate of lime or the phosphates and carbonates of the alkaline earths in considerable quantities were quite the exception—for example, of stones removed from 74 cases, including both primary and secondary calculi, 26 consisted partly of oxalate of lime; 31 contained a considerable proportion of phosphates; in 9 the character of the stone is not specifically stated, but the history of the cases would indicate that these were phosphatic stones, or at least contained a considerable proportion of phosphates. One stone consisted chiefly of sulphur and 1 of xanthin. The pure uric-acid and urate stones numbered 6—that is to say, eight per cent of the entire number.

In order to conduct certain experiments in regard to the detection of renal calculi, by means of the X-rays, I collected a considerable number of calculi from different sources, from surgeons of my acquaintance and from museums.

I chose only such calculi as were believed to consist solely or chiefly of uric acid. Upon having these calculi subjected to chemical analysis, out of 20 stones acquired from various sources, but 1 was found to consist of uric acid or its salts in what might be fairly called a pure state. The others contained a variable quantity of oxalate of lime or of phosphates.

(For the bearing of these observations upon the X-ray diagnosis of kidney stone, see X-rays.)

I do not believe it possible to detect pure uric-acid calculi by means of the X-rays. Theoretically, it is generally assumed that for the formation of stone an organic nucleus is necessary, but it is evident that such a nucleus may consist of a single degenerated blood cell or the minutest fragment of mucus.

An unduly concentrated urine is supposed to favor the production of calculus, and urine containing an excess of a variety of ingredients may be assumed to be a condition favorable for the precipitation of such ingredients.

The disease appears to be slightly more common in men than in women, and climatic conditions and qualities of drinking water appear in certain not

entirely evident ways to favor the condition. In general, defective metabolism from any cause seems strongly to predispose to renal calculus.

Mode of life, apparently, has some influence; a sedentary life, a nitrogenous diet, and the use of alcohol seem in some cases to determine the formation of calculus. On the other hand, among the people who subsist chiefly upon carbohydrates and who live and work vigorously out of doors, renal calculus is common enough.

In by far the largest proportion of cases the formation of renal calculus takes place in the renal pelvis or one of the calices.

The occurrence of kidney stone in the parenchyma of the organ belongs to the surgical rarities; a few such cases only have been reported.

In size and shape the greatest diversity exists. The stones may be minute, constituting the condition known as gravel, or, in certain instances, a stone or stones weighing several ounces have been removed from the kidney.

FIG. 126a. — X-RAY PICTURE BY THE AUTHOR OF DR. ELIOT'S CASE OF STONE IN THE KIDNEY.

The stones may be rounded or irregular in shape, or may form a complete cast of the dilated pelvis, calices, and beginning of the ureter.

The X-rays have demonstrated that a larger proportion of stones than was formerly supposed pass out of the pelvis of the kidney and find their way downward, to lodge in the intrapelvic portion of the ureter; thus Leonard found that among 30 cases in which the diagnosis of stone was made by means of the X-rays, the stones occupied the ureter in 19 cases.

Changes Produced in the Kidney by the Presence of Stones.—The changes produced in the kidney by the presence of stones in the pelvis or in the ureter depend upon a variety of conditions.

An important distinction is to be drawn between the cases in which the kidney remains in an aseptic condition and those in which infection occurs.

So long as no infection takes place the changes consist in an interstitial nephritis and a fatty or hyperplastic change in the fibrous and fatty capsules of the organ.

If the ureter becomes obstructed the kidneys may suffer in two ways. In case the obstructive process is gradual the pelvis of the kidney may become

Fig. 126b.—Renal Calculus. Weight, 21.742 grams. Composition, center—oxalate of lime; periphery—earthy phosphates. X-ray by the author shown in preceding figure. (Case of Dr. Ellsworth Eliot, Jr.)

dilated, and the kidney itself may be changed into a thin-walled sac, with disappearance, partial or complete, of the proper secretory and excretory substance—the condition, namely, of hydronephrosis.

Sudden and complete occlusion of the ureter, which persists, leads not to dilatation, but to atrophy of the kidney. The kidney becomes converted into a dense mass of fibrous tissue containing much fat, from which the kidney substance disappears.

In case infection occurs, the various phenomena of pyelitis, pyelonephritis, infected hydronephrosis, abscess of the kidney, or pyonephrosis are produced.

An extension of the infectious process beyond the kidney itself results in perinephritis and in abscess in the neighborhood of the kidney.

In certain rare cases pressure necrosis caused by the stone may lead to perforation of the renal pelvis or parenchyma, with the production of areas of granulation tissue in the perinephritic structures; and, in the absence of infection, this condition may exist without the formation of pus.

Symptoms of Calculus Formation.—The symptoms and physical signs of calculus formation may be considered under several heads:

1. Subjective symptoms.
2. Changes in the urine.
3. The physical signs to be recognized by palpation.
4. The evidence to be derived from the cystoscope, ureteral catheter, and ureteral sound.
5. The evidence to be derived from X-ray examinations.

Subjective Symptoms.—The subjective symptoms of kidney stones as well as of stone in the ureter consist of pain and of disturbances of urination. The pains may be broadly said to consist of sudden severe attacks of pain of

longer or shorter duration, and of more or less constant, though usually intermittent, pain of a less severe character. The severe attacks of pain are often spoken of as attacks of kidney colic.

The typical kidney colic is characterized by a sudden onset, and is of excruciating character; it is felt in the kidney region affected, along the course of the ureter, sometimes in the bladder, the testes, and external genitals. The pain may also radiate upward into the shoulder or down the thigh along the distribution of the anterior crural nerve. The pain is sometimes accompanied by vomiting, great prostration, sweating, by a constant desire to urinate, and in some cases by general convulsions. The attack may last for a few minutes, for hours, or for several days. *The pain generally subsides suddenly, leaving the individual quite free from discomfort.*

This typical history of an attack of renal colic is, clinically, the exception rather than the rule. Any one of the characteristic symptoms may be absent. The pain may be referred in such a manner as to lead to suspicion of disease of a different character. The symptoms may point to acute gastro-intestinal disturbance. The pain may closely resemble an attack of biliary colic. If the pain is localized in the epigastrium, is a general abdominal pain, or is felt chiefly on the right side of the abdomen, low down, it may be mistaken for disease of the appendix.

There are numerous instances in which kidney stone has been mistaken for scoliosis and for tuberculous disease of the bodies of the vertebræ.

It is also to be remembered that a number of conditions, other than stone, affecting the kidney may give rise to precisely the same train of symptoms.

The invasion of the kidney structure with tuberculosis, with its accompanying congestion and tension of the kidney capsule, may produce identical symptoms, and be accompanied by characteristic hematuria.

A new growth into which a hemorrhage takes place may exactly simulate a renal colic.

It is asserted by several authorities on the subject, although denied by others, that the pain may be located upon the opposite side of the body. My own observation supports the affirmative view.

Hemorrhagic pyelitis may give rise to symptoms precisely the same.

Kinks in the ureter, in cases of movable kidney, may give rise to similar attacks.

In general, *any condition which produces a sudden increase in the intracapsular tension of the kidney or which obstructs the ureter* may accurately simulate an attack of renal colic, an intra-abdominal tumor, or an aneurism—by pressure, for example.

There remain to be considered the very large group of cases in which the stone remains, so to speak, quiescent, giving rise to no symptoms at all, or at most to a slight amount of discomfort from time to time, or to symptoms hardly to be differentiated from those of ordinary functional gastro-intestinal disturbance.

In another class of cases the typical symptoms of renal colic are entirely wanting, and the patient may suffer from constant or intermittent pain, sometimes referred to the region of the kidney, often to the bladder, and not infrequently to distant parts of the body, as, for instance, the sole of the foot.

A large number of these cases are treated for bladder disturbance, none of the symptoms being referred to the kidney.

Calculous Anuria.—A patient who suffers from kidney stone may suddenly be seized with suppression of urine. If the other kidney is absent, destroyed, or seriously diseased, or if both ureters are obstructed at the same time, the condition will usually end in death in a few days, unless relieved by operative removal of the stone obstructing the ureter, or unless, as sometimes happens, the obstruction is partly or entirely overcome by natural means.

If the other kidney is sound it usually continues its function. Sometimes a reflex anuria, usually of a temporary character, may occur in this sound kidney also. In fact, it is probable that such reflex anuria in a sound kidney rarely if ever endures to a fatal issue.

The symptoms of the onset of urinary suppression from calculus differ to some extent from the ordinary symptoms of uremia.

At the beginning there is usually pain, referred to the kidney region or to the lumbar region, and down the course of the ureter. The pain may last throughout the attack, or more often will subside after hours or days.

Many of the symptoms may be referred to the bladder, as in an ordinary attack of renal colic.

When the obstruction is absolute, no urine may be passed after the beginning of the attack. If incomplete or intermittent, oliguria may alternate with polyuria. These are the cases in which hydronephrosis develops. The suppression is rarely so absolute as in ordinary cases of uremia, and, usually, small amounts of urine of low specific gravity will be voided, even though the case is to end fatally.

In case the useful kidney is hydronephrotic a certain tolerance appears to be established; and even if the obstruction is not overcome, death may be delayed for many days.

When uremic symptoms develop, they resemble those accompanying other forms of suppression, except that vomiting is more common and diarrhea less so.

Changes in the Urine.—The evidences furnished by the urine are valuable, although there are no data to be obtained from the urine, which enable us to make a certain diagnosis of kidney stone.

The urine may be entirely free from abnormal ingredients.

In certain cases the examination of the urine suggests merely a hyperemia of the kidney.

The urine frequently contains blood in small amount, constantly or only at intervals.

The blood in many cases is only discoverable under the microscope. There

will sometimes be a quantity of albumin present in the urine, slightly in excess of the amount of blood or of the number of pus cells, if such are present.

Sharp, and even dangerous, hemorrhage may occur, but such cases are the exception.

The type of bleeding which furnishes us with the strongest evidence of the presence of calculus is small in amount and frequently microscopic.

The number of blood cells present in the urine is often increased by muscular exertion, and entirely disappears when the individual is kept quiet.

When the hemorrhage is coincident with an attack of renal colic the bleeding usually continues for hours or days after the colic has subsided.

Blood casts of the renal tubules do not occur, nor are blood casts of the ureter at all common.

When the hemorrhage is severe, we must depend upon other physical signs and symptoms to exclude the presence of a malignant growth, an invasion of the kidney with tuberculosis, or the presence of a hemorrhagic pyelitis.

A moderate increase in the number of leucocytes contained in the urine, or even a mild catarrhal pyelitis, may exist without infection.

In the absence of lesions of the lower genito-urinary tract, the presence of a small quantity of blood, a trace of albumin, a moderate number of leucocytes in the urine is, when combined with attacks of renal pain, in the absence of tubercle bacilli and failure to appreciate a notable enlargement of the kidney on palpation, and especially if there is a previous history of the passage of calculi, strong presumptive evidence of the presence of stone.

When infection of the kidney has taken place and the urine is loaded with the products of inflammation, it is scarcely possible by urinary analysis to say whether the primary cause of the trouble is stone or some originally infectious process; indeed, a stone or stones are often found in the pelves of pyonephrotic kidneys, apparently as a secondary condition to the suppurative nephritis, and also in tuberculous kidneys in which secondary purulent infection has occurred, stone is not very rare.

These secondary cases of renal calculus present themselves to us more commonly as cases of pyonephrosis, perinephritic abscess, or other serious destructive lesion of the kidney, in which the stone plays a subordinate rôle from a pathological as well as from a diagnostic point of view.

In those cases of primary calculus where infection occurs, a series of signs and symptoms are exhibited, complex in character, and due in part to the presence of stone; either set of signs and symptoms may predominate in any variety of prominence.

Physical Signs and Symptoms to be Observed by Palpation.—Manifestly, the only positive signs of the presence of kidney stone discoverable by palpation are the actual appreciation of the stone under the examining fingers or a sensation of grating obtained by moving one stone upon another.

Such signs are rarely observed, and only in cases presenting stones of unusual size or in the persons of individuals unusually flabby and with thin

abdominal walls. Such cases must of necessity belong to the surgical rarities, and although occasionally observed and reported by surgeons, these signs can scarcely constitute a common means of diagnosis.

A physical sign to which many surgeons have attached much importance is the occurrence of pain elicited by a light, quick blow upon the last rib of the affected side, or localized tenderness on pressure just below the last rib. In the absence of pronounced changes in the urine and of other signs of serious disorganization of the kidney, this sign is often given a high diagnostic value, when taken in connection with subjective symptoms, such as commonly accompany the presence of a stone in the kidney.

Since the presence of a stone in the renal pelvis is not incompatible with a kidney normal in size, shape, and position, the existence of a tumor of any description corresponding to the situation of the kidney, or the absence of such a tumor, is not necessarily significant of the presence, or, on the other hand, of the absence, of stone.

Stone impacted in the lower end of the ureter may occasionally be felt *per rectum* or *per vaginam*.

The Cystoscope and Ureteral Catheter.—The cystoscope and ureteral catheter sometimes afford useful aid. A stone projecting through the opening of the ureter into the bladder can be seen through the cystoscope.

The ureteral catheter, when passed into the ureter, may meet with obstruction, and such obstruction may be due to stone.

A positive diagnosis even is possible, and has been made by inserting a wax-coated bougie into the ureter. The bougie coming in contact with the stone was moved back and forth, and scratch marks were found upon the surface of the wax, thus showing the presence of some hard, rough substance (Kelly).

The general conclusion must, then, be drawn, that in by far the largest proportion of cases no positive diagnosis of renal calculus can be made by the ordinary methods of examination. In many cases the operative exposure and examination of the kidney is necessary. (See X-rays in Surgical Diagnosis, Renal Calculus.)

CHAPTER XIX

TUMORS OF THE KIDNEY

A GREAT variety of tumors occur in the kidney. Some of them consist of structures belonging to the connective-tissue group, others are of the epithelial type, and certain kidney growths exhibit the characters of both these types of tissue; though all kidney tumors appear to be of mesoblastic origin. A very interesting group of tumors arise from congenitally misplaced portions of the suprarenal capsules, or adrenals, as they are sometimes called, and still others from vestiges of the mesonephros or Wolffian body. The fatty capsule of the kidney may also be the seat of tumor formation.

The *connective-tissue tumors* occurring in the kidney or its capsule are: Lipoma, fibroma, enchondroma, osteoma, angioma, lymphangioma, sarcoma, angiosarcoma, endothelioma, perithelioma, or perivascular angiosarcoma, and combinations of these various types. The *epithelial tumors* of the kidney are: Adenoma, cysto-adenoma, adeno-carcinoma, carcinoma. A peculiar and interesting tumor in a class by itself is the so-called *hypernephroma*—so named by Birch-Hirschfeld in 1896, although previously described by Grawitz in 1883. These tumors originate in the kidney from displaced portions of the adrenal body, or in the normally placed adrenal body itself. Some of them are very malignant; genetically the malignant forms are to be classed with the sarcomata, though portions of certain hypernephromata resemble carcinoma and adenoma in structure.

Another group of peculiar tumors occur in the kidney; they are known as embryonal adeno-sarcomata, teratomata, mixed tumors of the kidney. Other enlargements of the kidney occur which, though not properly classed with true tumors, will be described in this section; they are: Solitary cysts of the kidney, polycystic degeneration of the kidney and parasitic cysts (*echinococcus*).

General and Special Characters of Kidney Tumors.—The important tumors of the kidney occur for the most part during two distinct periods of life—namely, in infancy, including early childhood, and after the fortieth year of life. It is to be noted that tuberculosis of the kidney occurs most often between the twentieth and fortieth years, and rather rarely either earlier or later, a fact worth bearing in mind, since, with the exception of the embryonal adeno-sarcomata of infants, the malignant tumors of the kidney are commonly attended by hematuria; indeed, this symptom is the one which most often first attracts the patient's attention, and, as has been pointed out, an attack of hematuria is not an infrequent incident in early tuberculosis of the kidney.

Malignant tumors of the kidney are twice as frequent in men as in women; among women, however, a larger proportion of the cases of malignant new growth seek medical aid at a time when the tumors have ceased to be operable than is the case among men. This was noted especially by James Israel, and is explained by him on the ground that in women, especially such as have borne children, the abdominal walls are relaxed, and the belly may contain a considerable tumor mass without discomfort. In men, on the other hand, the belly wall is more rigid, less readily distended; they are, therefore, more apt to have pressure symptoms from a tumor of moderate size; moreover, *hematuria*, one of the most constant symptoms of malignant tumors of the kidney, attracts but little attention among women, and is commonly referred by them to a regular or irregular menstrual source, whereas among men hematuria is a very alarming symptom indeed. Thus, J. Israel saw, among 68 cases of malignant tumor of the kidney, 45 males and 23 females; 9, or 20 per cent, of the males were inoperable; 11, or 48 per cent, of the females.

General Prognosis of Malignant Tumors of the Kidney.—The general prognosis of malignant tumors of the kidney is exceedingly bad, largely owing to the fact that the growths are rarely recognized until they have reached a considerable size and have either invaded neighboring structures or have formed metastases, rendering a radical cure almost impossible.

A consideration of some cases which I saw in the Roosevelt Hospital, 1890–1900, and of others operated upon in the New York Hospital by several members of the attending staff since 1900–1908, is of interest in this connection. The Roosevelt Hospital cases of which I have record numbered 6, and did not include cases manifestly inoperable upon physical examination. The New York Hospital cases numbered 14. Of the 20 cases, 10 were males, 10 were females. The cases fall into two groups in reference to age—5 were children aged two, two and a half, three and a half, seven, and ten years respectively; the remaining 15 were persons whose average age was forty-five years. Of the 5 children the tumors had the following characters:

Round-celled sarcoma	1
Mixed tumor—embryonal adeno-myochondrosarcoma	2
Mixed tumor, probably involving both halves of a horseshoe kidney	1
Mixed-celled sarcoma	1

Among the 14 adults the characters of the tumors were as follows:

Carcinoma	4
Cysto-sarcoma	1
Adeno-sarcoma	3
Sarcoma	3
Hypernephroma	3
Unknown character, no operation	1

Among the 20 cases, upon 6 an exploratory operation was done, the tumor exposed and found inoperable on account of involvement of other structures. Upon 2 recurrent cases, the presence of glandular involvement or of metastatic tumors or of secondary tumors scattered through the belly prevented any attempt at removal. Upon 12 nephrectomy was done; 6 of these died as the immediate result of the operation. Two lived three months and died of rapidly growing recurrences. One lived a year and died with a very extensive recurrence. Two left the hospital well; their fate is at present unknown to me. In only 2 cases did the conditions appear favorable for cure at the time the kidney was removed; both were cases of hypernephroma. In 1, a tumor the size of a tennis ball projected from the lower pole of the kidney; there appeared to be no secondary tumors nor involvement of surrounding structures. Within a year the patient, a man of fifty-five, had an inoperable recurrence involving both sides of the abdomen. He died as the result of an exploratory incision.

J. Israel's statistics in regard to cures are notably better. He was fortunate enough to see a considerable proportion of his cases early, and skillful enough to diagnosticate them. A *résumé* of his published cases is as follows:

Of 43 nephrectomies for malignant disease, 8 died as the result of operation. One died after seventeen days as the result of rupture of the ascending colon due to an accumulation of feces which could not be evacuated. At the time of publication, three years or more had elapsed since the operation in 29 cases; of these, 7 died, either as the result of operation or of some intercurrent disease, less than three years after operation. Of the remaining 22, 14 died of recurrences. Eight have remained well more than three years; of these, the character of the tumor and the duration of freedom were as follows:

14 years	Carcinoma
12 years 7 months	Alveolar sarcoma
8 years 2 months	Spindle-celled sarcoma
6 years 6 months	Hypernephroma
5 years 8 months	Hypernephroma
5 years 3 months	Malignant adenoma?
5 years 3 months	Malignant tumor

Israel points out that 3 of the cases were operated upon at a very early period. In 2 the tumor was no larger than a cherry, in 1 no larger than a plum. He believes that if recurrence does not occur in two years the probabilities are in favor of cure, since, as is well established by the general experience of surgeons, recurrences are prone to appear very early after the removal of malignant tumors of the kidney.

In 1902 Schmieder—among other statistics in regard to the results of operations upon the kidneys—collected 329 nephrectomies for malignant growths of all kinds. Of these, 221 survived the operation; 20, or 6.1 per cent,

remained well at the end of three years. In a series of 145 cases of embryonal adeno-sarcoma, mixed tumor of the kidney in children, collected by Walker in 1897, 74 were operated upon. Twenty-seven died of the operation; 28 died of early recurrences. In 15 cases the fate of the patients was unknown. Four only remained free from recurrence three years or more. One was a case of Hans Schmidt; 1 of J. Israel; 2 were cases of Robert Abbe. Dr. Abbe informed me, January, 1907, that 1 of these, operated on twelve years ago, was then in perfect health. At the time of operation she was an infant. The tumor weighed seven and a half pounds. The child after the removal of the tumor weighed fifteen pounds. The tumor was of a sarcomatous type and contained much striped muscle fiber. The second case developed general anasarca and uremic symptoms quite suddenly three and a half years after operation. The remaining kidney was found to be the seat of a similar tumor; there was no recurrence at the site of the former operation.

The prognosis of *malignant hypernephroma* is, also, very unfavorable. James Israel had among 17 operations 4 immediate deaths, and 5 deaths from metastatic tumors. At the time of publication 7 were alive; 4, more than two years; 3, more than five years after operation. Charles L. Scudder reports 11 cases from the Massachusetts General Hospital (*Annals of Surgery*, December, 1906). Three were cases of his own. At the time of writing all were dead but 1; this case had been operated upon one year before for a tumor of the humerus. Amputation at the shoulder-joint was done; the tumor proved to be a hypernephroma. Subsequent palpation of the belly showed the left kidney movable and somewhat enlarged; the kidney was not operated upon. The man was in fair health but pale and cachectic-looking; there were no symptoms referable to the kidney. The metastases of hypernephroma occur, for the most part, in the lungs, the liver, and the bones, though they may occur anywhere. Joseph A. Blake saw one in the soft parts of the leg, associated with gummata in an elderly man.

As illustrating the fact that the original tumor may remain small and produce no symptoms while the metastases form rapidly growing tumors, I will mention a case of my own: In this case the patient was a man fifty years old. He had never had any symptoms referable to the kidneys, nor was I able at any time to detect any enlargement of these organs. He presented himself at the hospital with two rapidly growing tumors; one in the dorsal region involved the thick muscles of the back, the other in front grew from the third rib. Clinically these tumors resembled rapidly growing soft sarcomata. The patient was pale and cachectic. The tumors were removed. The wounds healed.

Pathological Report.—Hypernephroma. The patient was lost sight of and is, doubtless, dead, since the operation was done more than three years ago.

Pathological Anatomy and Clinical Characters of Kidney Tumors.—Some knowledge of the pathological anatomy of kidney tumors is necessary for an intelligent diagnosis of these growths, accordingly a few details are here given.

Lipomata.—We have already described the deposition of fat which takes place in the capsule of the kidney as the result of irritation, notably in cases of renal calculi with atrophy of the kidney and in old cases of pyonephrosis. Lipomata of the kidney may arise from congenitally misplaced portions of the fatty or fibrous capsules. They are very rarely composed of pure fatty tissue, nearly always they contain unstriped muscle fiber or are combinations with fibroma or myxoma. The researches of Grawitz seem to point to a suprarenal origin of some of these tumors, the original suprarenal tissue having changed its character by an abnormal deposition of fat in its cells, while a sort of fibrous capsule is furnished to the tumor by the fibrous stroma of the kidney itself. Such tumors are rarely if ever of surgical interest. (See Hypernephroma.) They might best be designated *Pseudo-lipomata*. They are usually very small tumors, and are discovered while operating upon kidneys for other conditions, or at autopsy.

Capsular Lipomata.—The lipomata developing in the fatty capsule of the kidney are rarely pure lipomata. They contain much fibrous tissue, sometimes smooth muscular fiber. Myxomatous degeneration is not uncommon; necrosis and suppuration of either the whole or a portion of a tumor has been observed. A moderate number of these tumors are recorded. Sometimes they have reached a large size; thus, one reported by Tillmanns weighed 10 kilos, another reported by Thiariar weighed 11.5 kilos; the patient was a woman aged sixty-three.

In regard to the diagnosis of capsular fibro-lipomata it may be said that they are rather slowly growing tumors. Pain, disturbances of urination, and hematuria are usually absent, so that in many cases the tumor has reached a considerable size before it has attracted the patient's attention. There may then be dull pain in the abdomen, back, and thighs, from pressure on the spinal nerves. Digestive disturbances, etc., and dyspnea may be present as in any large abdominal growth. Upon palpation these tumors, notably if softened by myxomatous degeneration, may give a feeling of fluctuation and have been mistaken for ovarian cysts.

Adami says in regard to the diagnosis of perinephric fibro-lipomata:

> A retroperitoneal (including perinephric) lipoma may be suspected where there is a very slowly growing tumor situated most often more to one side than the other, accompanied by little disturbance of the general health, save progressive emaciation and eventual dyspnea, which is crossed by a length of intestine and gives a sense of fluctuation, from which repeated punctures fail to draw any fluid. This sense of fluctuation distinguishes lipoma from sarcoma, and to some extent from myxoma.

It is perhaps needless to state, at the present time, that an aseptic incision is a far more safe and certain method of diagnosis than the introduction of an aspirating needle into an abdominal tumor the nature of which is unknown.

A single case of *multiple lipomata* of the kidney having peculiar characters was described by Alsberg in 1890.

Fibroma.—A few cases of fibro-myxoma and fibro-cystoma of the kidney have been recorded. It would be inpossible to differentiate them from other forms of renal growth before operation. Dr. F. W. Murray removed a kidney containing a fibroma at the New York Hospital (see Fig. 127).

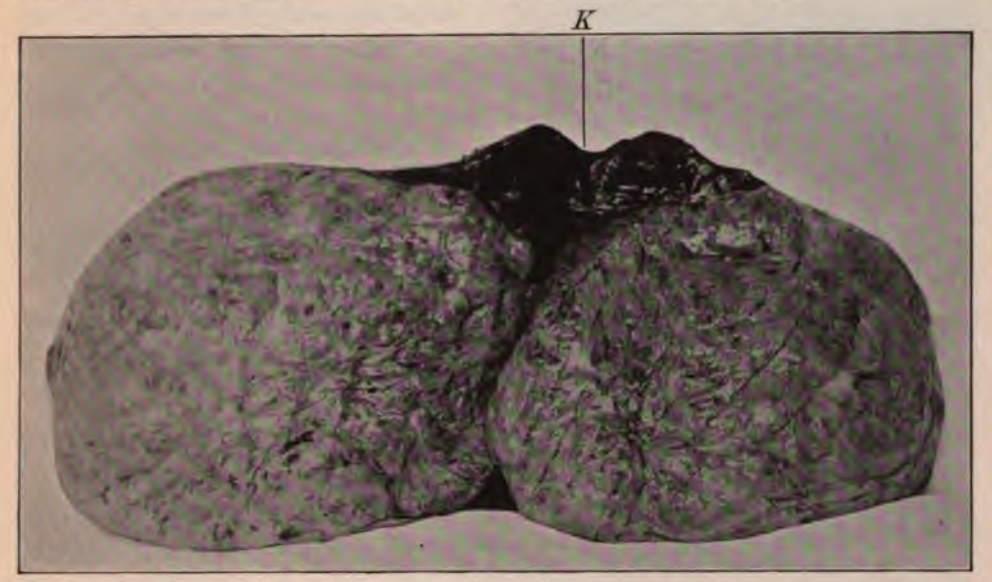

Fig. 127.—Fibroma of the Kidney. The patient was a young Italian woman, age twenty-six. There was nothing in her family or personal history which bore upon the immediate illness. Four or five years before she was seen by Dr. Murray, she noticed a small swelling in the region of the kidney. Beyond slight pain it gave her no inconvenience whatever. There was no frequency of urination, there was no hematuria. The tumor was on the right side; it occupied the right lumbar region, extended downward into the right iliac fossa and upward under the liver. The tumor was larger than a child's head at term, it was hard and elastic, not painful on pressure, freely movable, it could be moved across the median line to the left side and downward into the pelvis. It was removed without much difficulty by Dr. F. W. Murray. The patient made a good recovery. The major portion of the kidney had been destroyed by pressure. As shown in the figure but little kidney tissue remained.

Adenoma.—Nonmalignant adenomata occur in the kidney not very rarely. They are usually small encapsulated tumors and seldom grow so large as to require removal; a few such only have been recorded. In the kidney an alveolar or papillary mode of growth may characterize the individual tumor or the two forms may coexist. They may undergo cystic or other degeneration. Occasionally they form metastases, though the original tumor may preserve its simple adenomatous character (malignant adenoma). They may also take on an atypical cell proliferation and, as in the breast, break through their inclosing capsule and become adeno-carcinomata.

Carcinoma of the Kidney.—Primary carcinoma of the kidney may occur as an infiltrating or as a nodular tumor. As described under Tumors the physical characters of the growth will vary with the relative proportion of cellular elements and fibrous stroma; if the former predominate the tumor will be soft and juicy; if the latter, harder and tougher. (See Carcinoma, under Tumors.)

The *adeno-carcinomata* usually form masses which may be hard, soft, or fluctuating. They are not distinguished by the signs and symptoms from other forms of malignant growth. The infiltrating type of cancer may give rise to no palpable tumor, though the kidney is already entirely destroyed, or, on the other hand, they may produce merely an enlargement of the organ without changing its shape. Like other carcinomata, kidney cancers occur commonly during the later decades of life, but adeno-carcinoma may occur much earlier. They may be attended by subjective sensations of pain or not, or by a feeling of dragging or heaviness in the loin, though obviously such symptoms are in no wise characteristic. In many cases the condition of the patient will be hopeless before he seeks medical aid. A gradually developing cachexia may be all that attracts his attention. This is more likely to be true in those cases in which hematuria does not occur—amounting to twenty-five per cent of kidney cancers. The infiltrating forms, and those originating in a papilla or in the renal pelvis, usually bleed; the adeno-carcinomata frequently do not. Occasionally the appearance of tumor cells or of fragments of tumor tissue in the urine may aid in the diagnosis. More often the cells, if found, present no distinctive characters; they are usually swollen, globular bodies whose nuclei have disappeared, the protoplasm being represented by numerous fat droplets. (See Symptoms and Diagnosis.)

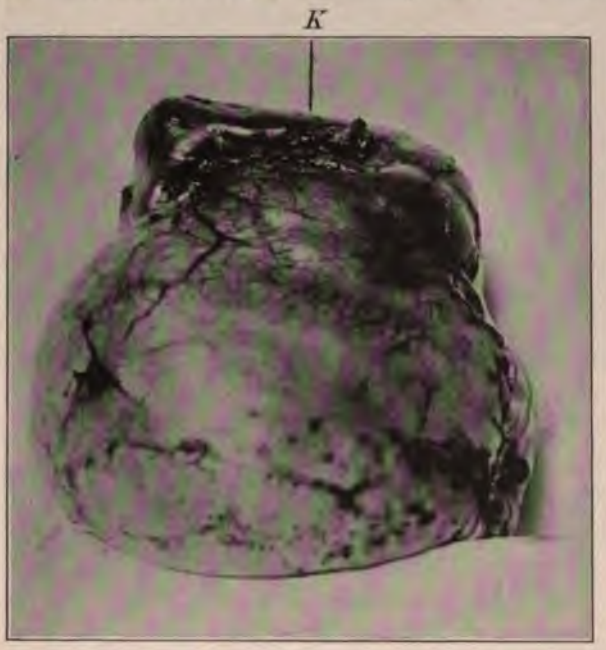

FIG. 128.—FIBROMA OF THE KIDNEY SUCCESSFULLY REMOVED BY DR. F. W. MURRAY AT THE NEW YORK HOSPITAL. At *K* the projection from the tumor represents the kidney.

SARCOMA.—Nearly every variety of sarcoma has been observed in the kidney, and here, as elsewhere, these tumors exhibit every possible grade of malignancy. The hard, slowly growing forms may remain encapsulated and movable for long periods; the soft, rapidly growing types may early infiltrate surrounding structures, grow into the blood-vessels, and produce rapidly fatal metastases. Invasion of the renal vein and vena cava are common events, thus rendering the formation of sarcomatous emboli probable. Cystic degeneration and hemorrhages into the substance of these tumors may change an originally solid growth rapidly into a soft or fluctuating one, and such tumors may

exhibit hard areas, alternating with soft and fluctuating spots; they may readily be mistaken for cystic tumors under these conditions. Hematuria occurs, according to Chevalier, in fifty per cent of all kidney sarcomata among adults. In general the sarcomata are apt to form larger tumors than the carcinomata; they may occur at any age.

FIG. 129.—MIXED-CELLED SARCOMA OF THE KIDNEY REMOVED BY THE AUTHOR. The patient was a boy aged seven. No symptoms had been produced by the tumor except anemia and gradual loss of flesh and strength. The tumor contained round- and spindle-shaped cells. It was of the infiltrating type and although a portion of the outer surface of the kidney was preserved nearly all of the kidney substance was replaced by tumor tissue. (See Plate III.) The child survived the operation but there were evidences of recurrence at the end of three months.

Angiosarcoma, Endothelioma, Perithelioma of the Kidney.—According to what he believed to be the origin of these several tumors, Manasse classified them as *endotheliomata of the blood-vessels, endotheliomata of the lymph vessels, and perivascular sarcomata.* The distinctions are of purely scientific, not of practical interest. The origin of these tumors has proved a puzzle to pathologists for years, nor can it be said that their genesis is clearly proven to the satisfaction of all at the present time. The different varieties are hard to distinguish under the microscope even by the most skillful, and then only by study of the histology of the most recent portions of the growth. Clinically they are not to be differentiated from other forms of soft vascular sarcomata; indeed, they often occur in combination with ordinary forms of sarcoma. I refer the reader to Manasse's original articles: "The Histology and Histogenesis of the Primary Tumors of the Kidney," Virchow's *Archiv*, vols. cxlii, cxliii, cxlv, 1895–1896.

The Embryonal Adeno-sarcoma of the Kidney—Mixed Tumor—Teratoma of the Kidney.—These tumors are congenital or occur during the earliest years of life, very rarely, if ever, occurring as late as puberty; they are, indeed, rare after the fifth year. The oldest case on record, that of J. Israel, was fourteen years of age. I saw one in Roosevelt Hospital in a boy of ten. They are believed to originate in persistent vestiges of the mesonephros, as do, also, certain similar tumors of the testis and parovarium. *Histologically* they exhibit epithelial and connective-tissue structures in varying proportions. Adenomatous and carcinomatous areas alternate with rapidly proliferating

undifferentiated embryonal tissue, with typical sarcomatous tissue, with cartilage, striped muscular fiber, etc. *Clinically* they are characterized by an extraordinarily rapid growth, usually by absence of all symptoms pointing to disturbances of the kidney, hematuria being observed throughout the whole course of the disease in only twenty-five per cent of the cases. They usually remain encapsulated even after they have reached a very large size. Their tendency to produce metastases is slight, and occurs only through extension into the renal vein or cava, or by direct extension of the tumor after perforation of the capsule. Infection of other structures through the lymph channels does not occur. The dividing line between the tumor tissue and the normal kidney surface remains sharp and distinct; no such infiltration of kidney parenchyma occurs, as is observed in the true cancers developed during later life. Destruction of the kidney, if it occurs at all, is caused by pressure. Thus in one of the Roosevelt Hospital cases the pathological report was as follows:

Pathological Report.—The tumor was of globular shape. Dimensions: Weight, 9¾ pounds. Circumference in three planes—25½, 27, and 23½ inches. The tumor was distinctly encapsulated; its surface was smooth, except for two hemispherical projections, which were of softer consistence. From the lower end of the tumor there projected a pedunculated mass measuring 4 × 3 × 2 inches, with a pedicle 2½ inches wide and ½ inch thick. This mass was of firm consistence, and upon it the colon lay, and was adherent to it. On section the surface was smooth and dotted with irregular areas of necrosis. The tissue was soft and friable. At the upper and back part of the tumor lay the kidney, apparently merged at its lower pole into the mass. On section the kidney was normal; there was a sharp line of demarcation between it and the tumor.

Microscopical Diagnosis.—Myo-chondroadeno-sarcoma, carcinoma, teratoma.

The interference with the general health of the child is often trifling. Unlike some other malignant growths of the kidney these tumors do not produce amyloid degeneration of the abdominal organs nor any marked cachexia. Unfortunately, in the absence of symptoms, other than the enlargement of the abdomen, parents rarely bring their infants to the surgeon until the tumor has reached an enormous size. If operated upon early the prognosis would, doubtless, be much better than it is—i. e., very bad.

Hypernephromata.—During embryonic life the suprarenal bodies, or adrenals, inclose at one period nearly the whole upper half of what at that time is the distinctly lobulated fetal kidney, and it frequently happens that small portions of such adrenals become inclosed in the substance of the kidney as it increases in size, presumably in the crevices between the lobules; thus we find not infrequently in adult kidneys larger or smaller portions of adrenal tissue lying beneath the kidney capsule. Such tissue bears distinctive characters, such that it is readily identified with the cells of the normal adrenal gland, sometimes but one type of such cells being represented, sometimes all the types which occur in the adrenal body.

PLATE III

Fig. 1.

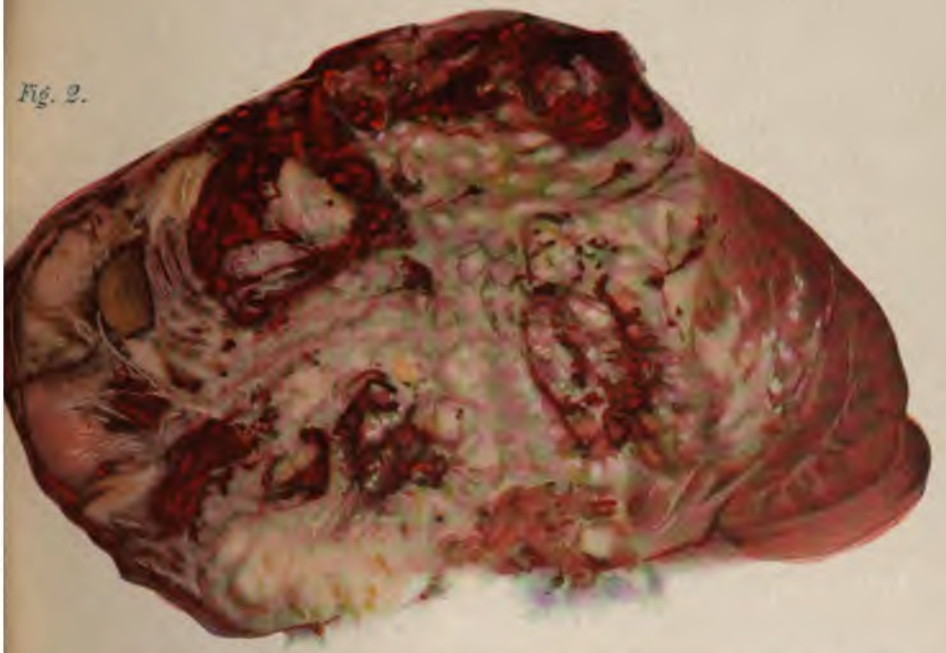

Fig. 2.

FIG. 1.—SARCOMA OF THE KIDNEY REMOVED FROM THE CHILD WHOSE PHOTOGRAPH IS SHOWN IN FIG. 129.
FIG. 2.—CUT SURFACE OF TUMOR SHOWN IN FIG. 1. THE REMAINS OF THE KIDNEY ARE SHOWN ON THE RIGHT. THE ORGAN WAS DISPLACED DOWNWARD AND OCCUPIED THE LOWER AND POSTERIOR PORTION OF THE TUMOR. FIG. 1 IS A VIEW OF THE TUMOR AS SEEN FROM THE FRONT. IN FIG. 2 THE RAGGED BORDER OF THE TUMOR TO THE LEFT OF THE KIDNEY REPRESENTS THE POSITION OF THE PEDICLE. TUMOR TISSUE SURROUNDED THE RENAL VEIN AND EXTENDED UPWARD A CONSIDERABLE DISTANCE UPON THE AORTA AND VENA CAVA. A CLEAN DISSECTION AND REMOVAL OF ALL THE *TUMOR TISSUE WAS IMPOSSIBLE.*

In the majority of cases adrenal inclusions remain innocuous throughout life, in a few during adult life the adrenal tissue takes on an active and abnormal growth, which may form a malignant tumor, the general arrangement of whose tissue elements is that of a sarcoma, although a more or less perfect glandular arrangement may be present in certain parts of the growth, and the cells may resemble epithelia of various types. Some of these tumors are as malignant as any afflicting the human body. Their appearance during childhood is very rare.

Histology of Hypernephromata.—A few of the characters are here given (the details are adapted from Schede). The vestiges of suprarenal tissue found in the kidney, some of which lead to the production of tumors, may be divided into several groups:

(1) Minute tumor masses embedded in the cortex of the kidney, containing fat, and called by Grawitz, lipomata, consisting of adrenal tissue merely, in which each of the three layers of normal adrenal gland are represented—i. e., cortex, pigmented zone, and medullary substance; these are to be recognized as merely included portions of suprarenal tissue rather than as tumors arising from the same.

(2) The true type of tumor accessoria: they are larger lobulated tumors containing fat, of a whitish, yellowish, or yellowish-red color and rather soft consistence. They lie beneath the kidney capsule, more often at the upper pole. They are divided into larger or smaller lobules by a notably translucent framework of connective tissue and are separated from the displaced kidney parenchyma by a fibrous capsule. Under the microscope there is distinguishable a delicate connective-tissue stroma consisting chiefly of a network of capillaries and small veins. In the meshes of this network, separated by delicate septa, lie cylinders or groups of cells resembling epithelia—cubical, round, or polygonal in shape. The cell cylinders are often arranged in parallel columns and are much more slender than the similar cylinders found in the normal cortex of the suprarenal body. In other cases the cells are grouped into balls of considerable size, but there is never the suggestion of the formation of canals or of cavities. The size of the cells is, on the average, the same. They possess an easily stained nucleus, and in the fresh state contain much fat, in larger or smaller droplets (removed by alcohol). The cells contain glycogen in the form of a hyaline deposit in globular or irregularly shaped masses, completely or partly filling them, and staining intensely brown upon the addition of iodin solution. These tumors resemble the primary adenomata of the suprarenal bodies and present a purely hyperplastic growth of the displaced adrenal germ. They are entirely benign tumors.

(3) A third group are characterized not only by a very marked growth of the cell complex, but also of individual cells, so that not only are the number of cells increased, but the individual cells are increased in size. They reach the proportion of giant cells and develop numerous, large, shapeless nuclei, so that they are not recognizable as suprarenal cells. Lubarsch and Manasse have called attention to the presence of these cells in kidney tumors, and the latter to their presence in suprarenal adenomata.

(4) A very rare form, apparently a pure hyperplastic growth of cells of the medullary layer of the suprarenal body, but occurring in the cortex of the kidney.

Manasse described a tumor of this sort as large as a hen's egg, found at autopsy, which consisted almost entirely of suprarenal medullary substance—namely, of groups of dark-brown or yellow cells, separated from one another by delicate bundles of connective tissue. The smallest of these resembled the cells of normal suprarenal medullary substance. Others were larger, quadrilateral, rounded, wedge-shaped. Others were giant cells of colossal dimensions and of unusual forms. The smaller cells formed waving lines or strings of cells as in the normal suprarenal tissue; the larger, irregular clumps.

(5) While the forms already described contained only a meshwork of connective tissue filled with solid masses of cells, this form contains, also, cavities and tubules lined with epithelia.

(6) The formation of cysts, cavities, and tubules in a hypernephroma appear to be the characters which determine its malignancy; yet in certain malignant hypernephromata no cavities are formed.

Characters of Hypernephromata When Malignant.—The characters of hypernephromata when malignant are as follows: They form nodular masses of yellowish or yellowish-red color; the central portions are firm; the peripheral parts are softer, sometimes as soft as brain matter. They partly push aside and partly infiltrate, and thus destroy surrounding structures, while forming new nodules in the vicinity. The tumor masses frequently penetrate into the renal pelvis, and may fill it or grow farther into the ureter. In the center of the tumor there may occur translucent masses of connective tissue; edema and hyaline degeneration of such masses is not infrequent. The tumor is divided into lobules by a more or less coarse framework of connective-tissue septa containing the blood-vessels. Within the lobules the cells are supported by a delicate meshwork of connective-tissue fibers, sometimes by capillaries lined with endothelium. The meshes are filled with cubical or polygonal cells containing much or little protoplasm, and are often of a golden-yellow color; the cells may contain fat droplets and glycogen; the cells are arranged in solid strings, or in groups suggesting in appearance one of the acini of the liver. In other parts glandular tubules appear lined by a single layer or by stratified epithelium; such tubules may contain blood. Alveoli are often formed, filled with cells or partly empty, from whose walls papillary outgrowths of cells protrude, or cysts may be seen varying in size from very minute to the size of a pea, of a cherry, or larger. Such cysts are often found on the periphery of the tumor, and may contain clear colorless liquid, or blood, or atheromatous material. In the older portions of the growth there occur areas of cystic degeneration containing blood or bloody fluid. There is a marked tendency for the tumor masses to grow directly into the renal vein or vena cava, and this event, doubtless, in many cases marks the change between a slowly growing circumscribed tumor and a growth of the most malignant character, with the rapid formation of metastases and systemic poisoning.

The hypernephromata exhibit in their structure two distinct types of malignant new growth—sarcoma and carcinoma—but, since the structures from

hich they originate do, in the normal course of their development, exhibit both he connective tissue and the epithelial type of structure and cellular form, he explanation is not difficult. It is not to be forgotten in this connection hat the mesoblastic germinal layer may furnish epithelial cells and distinctly landular organs, as well as bone, cartilage, muscle, etc.—the kidney being, for xample, an organ containing typical epithelium and yet of purely mesoblastic rigin.

Clinical Characters of Hypernephroma.—The clinical characters of hypernephroma are peculiar; some of them have already been noted. These tumors may long remain innocent and produce no symptoms. They may grow slowly for many years, and reach a considerable size unknown to their possessor, and then suddenly, either by invasion of the renal pelvis or by direct extension into the larger veins, cause serious symptoms—such as marked hematuria; or, on the other hand, produce metastases of a dangerous or fatal character, together with a general toxemia and profound anemia. In addition to anemia, amyloid degeneration of the glandular organs of the belly is one of the later lesions of the disease. Metastases by way of the lymphatics is supposed rarely if ever to occur. In other cases the original tumor will grow rapidly and cause symptoms, such as are caused by any malignant tumor of the kidney. In others the original growth remains small, while the metastases are rapidly growing and dangerous. With rare exceptions the tumor runs a latent course until after the fortieth year of life.

Symptoms.—The symptoms when they appear are, in a large proportion of cases, first, hematuria, accompanied or not by an attack of renal colic, according to whether or not the ureter is plugged by clots. In some cases the patient may have been conscious of a sense of weight, of dragging, or of pressure in the loin or abdomen, or of dull pain; and in some cases these sensations will have led him to seek medical aid, when examination of the abdomen will disclose the presence of a tumor of the kidney. In other cases the attacks of hematuria may be repeated many times during a series of years, and yet the tumor will continue to grow but slowly, and give but few local symptoms.

Thus, in one of the New York Hospital cases, intermittent hematuria had existed for five years before the patient came to the hospital, and yet the tumor was so small that no enlargement of the kidney was detected by a skillful surgeon before operation. In another case hematuria had existed for eighteen months; the tumor was no larger than a tennis ball. In one of my own cases the patient had never had hematuria nor was any tumor discovered in the kidney region; the metastases were larger and rather superficial, as described. Cases are recorded where ten, twelve, and even more years have elapsed between the first attack of hematuria and death, or operation. The frequent occurrence of hematuria is readily explicable when we bear in mind that these tumors are composed of very soft and friable tissue and contain blood-vessels whose walls are very thin. Probably in many cases hematuria only occurs after the tumor has invaded the pelvis of the kidney.

The Metastases of Hypernephromata.—The metastases of hypernephromata are found for the most part, as stated, in the lungs, the liver, and the bones, but may occur elsewhere. They are usually caused by direct invasion of the renal vein or vena cava and the formation of infectious emboli of tumor cells.

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PRIMARY TUMORS OF THE RENAL PELVIS.—Primary tumors of the renal pelvis are rare; only a very small number have been reported. They may be epithelial growths—either innocent papillomata, or much more frequently epithelial cancers, either of the tubular or alveolar type. Among the tumors of the kidney pelvis of the connective-tissue type, Albarran reported four rhabdomyomata, one myxoma, one angiosarcoma, one lymphatic endothelioma. The papillomata are usually multiple tumors, and resemble the papillomata of the bladder. They tend to grow down into the ureter, and the diagnosis might be made by ureteral catheterization and the capture of a fragment of tumor tissue, or even, excluding the bladder, as a source by cystoscopy, by finding such fragments in the urine. The malignant forms tend to grow into the kidney like any malignant growth and to form metastases. The *symptoms* produced by the malignant forms are pain and hematuria, and, since they tend to plug the ureter, hematonephrosis, hemato-uronephrosis, or hemato-urcpyonephrosis are probable events. A nephrotomy would usually be necessary to establish the diagnosis.

Methods of Propagation of Malignant Tumors of the Kidney.—Malignant tumors of the kidney may infect other parts in a variety of ways: (1) By direct extension. (2) By growing into the large veins—vena cava and renal veins. (3) By the entrance of tumor cells into the smaller veins of the tumor

itself. (4) By the lymph channels. (5) By a descending infection of the ureter and bladder.

1. Involvement by direct extension occurs frequently in carcinomata, sarcomata, and hypernephromata, much less often in embryonal adeno-sarcomata of infants. The recognition of such extension before operation is not always easy. This is notably true of those tumors growing from the upper pole of the kidney, where often, though the symptoms point to a malignant new growth, no tumor can be felt; nor is it always easy, though the tumor may be large, since the mass may remain movable, and yet be quite beyond hope of operative cure, on account of invasion of other also movable organs. If, however, the tumor be found firmly fixed it is probably inoperable. However, the mere size of a tumor does not necessarily mean that it has broken through its capsule and invaded surrounding structures; this being especially true of the large tumors of infants, also, to some extent, of other forms. On the other hand, small tumors may already have produced metastases.

2. We have no certain means of knowing when the tumor has invaded the renal vein or cava; edema of the lower extremities, varicocele, or enlargement of the veins of the abdominal wall would suggest such a condition, but are rarely observed; when present, operation is useless.

3. The formation of metastases by the entrance of tumor cells into the small veins of the tumor itself seems to be the most frequent method of propagation. This is especially true of sarcomata, endotheliomata, and hypernephromata, and the localization of these secondary growths seem to be especially common in the bones. Therefore, when operating upon an apparently primary tumor of bone in a middle-aged adult it is always wise, first, to examine the kidney regions.

4. Infection through the lymph channels appears to be less common in tumors of the kidney than in malignant growths of other parts. As is to be expected, such infection is more frequent in carcinomata than in other forms. There is no means of telling in advance whether such infection has occurred or not. If the supraclavicular glands are found enlarged and hard no operation should be done. Infection through the lymph current is much more apt to occur after the tumor has broken through the *capsula propria* of the kidney.

5. Descending infection with tumor formation at the ureteral orifice or in the bladder wall has been observed in a few cases of cancer. The cystoscope should be used when disease of the bladder is suspected, and, on the other hand, tumor of the bladder should lead to careful examination of the kidneys.

Symptoms and Diagnosis of Malignant Tumors of the Kidney.—The most important signs and symptoms of tumors of the kidney are an enlargement of that organ, or the formation of a solid tumor in the loin, and the occurrence of hematuria. Additional data are pain, disturbance of general health, and the recognition of metastases. As has already been stated, it is very rare that patients present themselves for examination on account of a tumor in

the kidney region until it has reached a considerable size, and, only too often, is quite inoperable. Indeed, the detection of even a considerable tumor of the kidney is by no means always easy or possible, even for a skillful surgeon, if the tumor is growing from the upper pole of the kidney and lies against the diaphragm hidden beneath the ribs, or develops from the posterior surface of the kidney, or is associated upon the right side with an enlargement of the liver. Thus, the symptom hematuria, the earliest symptom observed by the patient in a large proportion of cases, becomes one of great consequence, and demands careful study. In Israel's cases hematuria was the first symptom of a disturbance of health in 70 per cent; this proportion is larger than that usually observed. Chevalier's statistics place it at 26.6 per cent. As stated, it is much less frequent in the mixed tumors of infants. In the remaining 30 per cent the first symptom complained of was either pain, or a sense of pressure in the loin, or loss of appetite, or emaciation, or weakness, disturbances of digestion, or the appearance of metastases, the primary tumor remaining latent.

Hematuria.—The occurrence of hematuria appears to bear no very definite relation to the size or age of the tumor. In some cases it has been absent, though the tumor was very large; in others it has occurred when the tumor was still very small, as already related; or, indeed, many years before the presence of a tumor was recognized. In many cases, as stated, hematuria may have occurred from time to time for years, and the tumor when examined may be large or small; notably is this true of hypernephroma. Since only by early operation can any of these patients be cured, the importance of hematuria as a symptom and the determination of its source are matters of great moment. Some remarks on hematuria in general are here in order.

Urethral Hemorrhage.—Bleeding from that part of the urethra anterior to the membranous portion closed by the *compressor urethræ* muscle in the male occurs independently of urination. The blood may simply exude from the meatus, or form long, thick clots, and be passed as such at the beginning of urination. The causes are trauma—external or internal; blows or falls upon the perineum; occasionally from coitus after the operation of internal urethrotomy, due to the rupture of adhesions; the passage of instruments into the urethra in cases of stricture, notably when undue force is used, with the production of a false passage. (See also Urethra.) *Bleeding from the prostatic portion of the urethra*, if slight in amount, as, for example, during posterior urethritis of gonorrheal origin, occurs at the end of urination as the muscles close upon the walls of the canal and express a few drops of blood, and is accompanied by pain in the glans penis, often by involuntary straining and tenesmus. Hemorrhage from the prostatic urethra, if considerable, flows back into the bladder, and is voided more or less evenly mixed with the urine. The quantity of blood in the urine may be larger at the beginning or at the end of urination, the intermediate portion being nearly or quite clear. The causes are trauma, prostatic hypertrophy, or tumor, tuberculosis, and stone.

(See Prostate.) Pain in the glans penis and vesical tenesmus are common symptoms.

Bladder Hemorrhage.—In bleeding from the bladder the blood may be evenly mixed with the urine, or the first portion of the urine may be clear, the last bloody. Large clots may form and cause extreme vesical tenesmus with retention of urine, requiring instrumental removal of the clots by suction through a catheter or evacuator tube. (See Bladder.) The causes are trauma, ulceration of the bladder (notably tuberculous), cystitis, etc.

Renal Hemorrhage.—The blood is usually evenly mixed with the urine; there may be large or small clots. Rarely the urine may be quite clear, and contain one or more small clots, apparently formed in the bladder itself.

The differentiation between bladder and kidney hemorrhage may sometimes be made by the following procedure: A catheter is introduced, and the bladder washed clean with sterile normal salt solution. The bladder is then refilled with water, and after waiting a few minutes is again emptied with the catheter. If the blood is coming from the ureter or kidney the fluid will usually be quite clear; if the blood is coming from the bladder wall or prostatic urethra the mechanical irritation of the washing will usually cause a continuance of the bleeding, so that the contents of the bladder becomes bloody at once; and a continuance of the washing results always in the evacuation of bloody fluid. The observer must, however, wash so thoroughly that he is sure he has actually removed all lurking clots before he draws his conclusions. The most certain method of excluding the bladder as a source of bleeding is by cystoscopic examination. If the urethra be excluded, and the bladder appears healthy, the blood must come from the kidney or ureter. As already stated in another place, if we are fortunate enough to make the examination while the bleeding is going on we sometimes see bloody urine coming from one papilla while that from the other is clear, or we may see a clot protruding from one ureteral orifice or clinging to its border. Certain fallacious conditions are, however, possible; a tumor of the kidney and one of the bladder may coexist, the latter being secondary to the former or not; we should, then, in the absence of a palpable tumor in the loin or other signs pointing to renal disturbances, probably refer the source of bleeding to the bladder alone. The same false conclusion might well be drawn in the presence of vesical calculus; or a renal calculus on one side might cause hematuria, while a tumor of the opposite kidney did not bleed. These possibilities should lead the surgeon to the most careful examination of the entire genito-urinary apparatus in every case.

Subjective Symptoms of Renal Hematuria.—While in certain cases hemorrhage from the kidney, even in large amount, may occur without pain or discomfort, in many cases the distention of the renal pelvis or plugging of the ureter with clots will be accompanied by a more or less typical renal colic, or by a dull pain, or sense of distention in the kidney region. Such symptoms occur in about half the cases of renal hematuria from tumor, and in most of these the pain and discomfort will be referred to the affected side.

Clinical Characters of Renal Hematuria due to Tumors of the Kidney.—Hematuria due to a tumor of the kidney often occurs suddenly without warning in an individual who has, up to that time, enjoyed perfect health. *Exercise or, on the other hand, rest in bed, have little or no influence upon its beginning, continuance, or cessation.* A single attack may take place, even during sleep, and cease, not to recur for months or, in the case of hypernephromata, for years. The patient may pass nearly pure blood, and at the next micturition his urine may be perfectly clear. In some cases successive specimens, passed through a series of days, will exhibit, without any regular sequence, clear urine without even microscopic evidences of blood, nearly pure blood, bloodless urine, urine containing a few blood cells, and, again, urine containing macroscopic quantities of blood. Israel considers that such a series of events is highly suggestive of malignant tumor of the kidney. I have observed the same condition of affairs in cases of tabes long under observation. In other cases the bleeding may be nearly continuous for weeks. In some cases the hematuria will be more marked and its occurrence more frequent with the age of the tumor, suggesting involvement of the renal pelvis. In others the bleeding occurs early in the disease, and later ceases. In a few cases violent muscular effort, overfatigue, or a violent shock to the body, such as a fall or even a drive over rough roads, has preceded the hemorrhage.

In the cases of very profuse bleeding the bladder may fill with clots, and in men, more rarely in women, cause retention of urine and extreme suffering. In less violent bleeding the blood will be evenly mixed with the urine, the color will usually suggest bright recent blood rather than the brownish discoloration observed in the hemorrhage from stone, or hemorrhagic nephritis (Israel). In addition to fluid blood, clots may be observed, sometimes partly decolorized. In some cases there occur clots of peculiar character, representing a cast of the ureter; such casts are long and slender, and must exceed four inches in length in order that a ureteral source may be assumed with certainty (Israel). Large, thick, leech coagula, two or three inches long, represent blood coagulated in the male urethra. Israel attaches a peculiar diagnostic value to the occurrence of coagula possessing a definite size, shape, and composition. His large experience in this field and his unusual care in the study of his cases lead me to quote his description:

> If worm-shaped coagula are passed with clear urine we may assume, independent of their length, that they have formed in the ureter. Sometimes by slowly pouring the bloody urine into a white plate we may observe that the apparently homogeneous coagula lying at the bottom are composed of longer or shorter fragments of ureteral casts. While these formations merely indicate a renal origin of the bleeding without indicating its cause, we sometimes meet with certain products of coagulation in slightly bloody or clear urine which, I think, may be regarded as pathognomonic of tumor of the kidney. They are soft, sometimes partly translucent coagula of reddish, feebly yellow or white color, of the size or form of a small worm or maggot, or of a short, thick gonorrheal shred; sometimes they are

longer, as much as 2 cm. in length with a diameter of 2 to 2.5 mm.; they are then slightly constricted in places and between the constrictions slightly fusiform. *Microscopically,* they consist of a fibrillated and granular fibrinous basement substance in which are embedded cellular elements in varying numbers—namely: red blood cells; swollen red blood cells, leucocytes, which are not infrequently stained a golden yellow by imbibition of the coloring matter of the blood; very large globular cells containing fat droplets, sometimes of a golden-yellow color, and large swollen epithelia. I have observed these structures in kidney tumors which have broken into the renal pelvis and have formed a slender conical projection into the beginning of the ureter. From such a projection the bloody fluid, sometimes containing tumor cells in a state of fatty degeneration, has dropped into the ureter like drops of water from a melting icicle, to coagulate into these short wormlike bodies. The slight narrowings observed represent the narrowed point which normally exists just below the upper part of the ureter.

Microscopic Hematuria and Other Abnormal Ingredients in the Urine.—A very large proportion of kidney tumors, in addition to macroscopic hematuria, occurring as described, have, from time to time, with clear urine, blood cells in the urine sufficient in number to be seen under the microscope, best by the use of the centrifuge. Their occurrence is not constant, nor are they of pathognomonic significance. *Albumin* is usually present, either as a trace or in quantity representing the degree of hematuria. If found in larger amounts it will represent degenerative or inflammatory changes in the remaining portion of kidney, and will be accompanied by casts. Still another source is possible—i. e., transudation from tumor tissue projecting into the renal pelvis. Other *cellular elements* are often present—leucocytes in moderate number; large, swollen, globular cells containing fat droplets; and epithelial cells of all shapes and sizes, often deformed and swollen, usually representing a desquamative process of the renal pelvis and ureter. The large globular cells are usually regarded as tumor cells in a state of fatty degeneration, and when they occur in large or enormous numbers they are, I believe, of diagnostic value, indicating a degenerative process in a tumor mass projecting into the renal pelvis. In other cases they may be present in moderate numbers without creating more than a suspicion of kidney tumor; indeed, they may be present in other irritative lesions, representing merely epithelial cells of the renal pelvis and ureter in a state of fatty degeneration. They have been observed in tumors which did not involve the renal pelvis in many cases. Breaking off and voidance through the urethra of portions of tumor tissue, such that a microscopic examination permits a positive diagnosis, is possible, though rare.

Palpation of Kidney Tumors.—I have little to add to what has been said under the Diagnosis of Abdominal Tumors. The recognition of malignant kidney tumors, while they are yet small, is of the highest importance for the patient; when operated upon very early cure is possible; in advanced cases death is almost certain. When the tumor has grown to a large size and projects well forward and downward below the costal arch, nothing is easier than

to recognize its presence by palpation. (See Tumors of the Abdomen.) If it occupies the upper pole of the kidney, and is small, it cannot be felt. If larger it may displace the kidney downward, and the surgeon, feeling the kidney more readily than is usually the case, may suspect the existence of a tumor as a cause for such displacement. A tumor growing from the posterior surface of the kidney is, of course, harder to discover than one occupying its lower pole, anterior surface, or convex border.

In making abdominal palpation for the examination of the kidney, the dorsal position or the semilateral position—the patient lying upon the sound side with the knees and thighs flexed—are both useful. The surgeon stands upon the side to be examined, places one hand upon the free ribs behind, one upon the abdomen in front, and while pressing firmly forward with one hand palpates below the costal arch in front with the finger tips of the other. In order to palpate deeply the following maneuver, elsewhere described in this book, is useful. At the moment of relaxation of the abdominal wall, between inspiration and expiration, the index and middle fingers are pressed firmly backward and upward beneath the costal arch, and the depression of the belly wall so gained is held until the next corresponding relaxation, when a further gain is obtained by additional pressure. In this way, if done slowly and gradually, it is sometimes possible to feel pretty well up the anterior surface of the kidney. Israel recommends this method with the idea that the kidney, as it descends during inspiration, is prevented by the pressure from resuming its former position, and thus becomes more accessible to palpation.

I am in the habit, if palpation is difficult, of making the examination under full ether narcosis, when I am usually able to feel more plainly that which was before uncertain. A number of surgeons do not recommend general narcosis for the diagnostic palpation of the kidney, and succeed better without it. The malignant tumors of the kidney usually feel firm and solid. In the infiltrating forms of cancer the kidney may preserve its shape, and simply feel larger than normal. In other cases the mass is rounded, ovoid, or globular; the surface may be smooth, or rounded knobs or bosses may be appreciable; there are no sharp edges, such as might be felt in enlargements of the liver or spleen. If the tumor is small and grows from the anterior surface or lower pole, and the patient has thin or relaxed abdominal walls, it is sometimes possible to distinguish it as a nodule or projection from the surface of the otherwise normal organ. Rapidly growing sarcomata and hypernephromata may, as stated, undergo partial cystic degeneration, or portions of the tumor may be the seat of large hemorrhages, so that softened and fluctuating areas may alternate with firm and solid portions. I should hesitate to use the aspirating needle as a diagnostic measure in tumors of the kidney, and believe an exploratory incision, to be followed by nephrectomy if practicable, a safer procedure.

Varicocele.—Varicocele upon the affected side, and of a grade entirely beyond the ordinary, is a rare symptom of tumors of the kidney. It is supposed to be due to pressure upon the spermatic vein, or to pressure by enlarge-

glands or the tumor itself upon the renal vein or cava, or to thrombosis of one or both of these veins. It is, however, absent in very large tumors in most cases, and may be present, though no enlarged glands exist. If upon the left side, and only moderate in degree and not of recent development, it is of no diagnostic significance. I have seen in one case an enormous varicocele with a large sarcoma of the left kidney. The patient died of the nephrectomy, no observations being made as to the direct cause of the varicocele. Israel saw but one case in which a left-sided varicocele appeared to depend upon a kidney tumor. Schede, in 20 cases, saw none. In the 20 cases reported from the New York and Roosevelt hospitals no case of varicocele is recorded.

Subjective Sensations in the Absence of Hematuria.—As stated, renal hematuria from malignant tumors of the kidney is often accompanied by renal colic, or by pain of a less characteristic kind. In the cases which do not bleed, pain and discomfort felt in the back or loin are not constant, nor even very frequent symptoms. They occurred in only 15 per cent of Israel's cases, and he considers that the absence of pain can in no wise be regarded as a condition rendering the presence of a tumor improbable. Chevalier, on the other hand, states that pain is an initial symptom among adults in 28 per cent, and among children in 7 per cent of all cases. When present the pain is apt to be continuous and dull, though in a few cases sharp attacks of colic have been observed, probably due to congestion of the kidney and increased tension of the kidney capsule or to hemorrhages within the tumor itself, common in sarcoma and hypernephroma. As in all irritative conditions of the kidney, frequent and painful urination may be present. Attacks of renal colic without bleeding may, of course, occur when the ureter is stopped from pressure or by the lodgment of a stone or a fragment of tumor tissue in the ureter or, as has been observed in rare cases, from torsion of the ureter.

Recognition of Conditions Contraindicating Operation.—As already stated, the mere size of a kidney tumor is no contraindication to its operative removal, since we have seen that very large growths, notably among infants, may still be encapsulated. When by palpation and inspection we discover that the tumor is rigidly fixed, and shows no respiratory mobility, operation will generally be useless. In true cancer of the kidney a diffuse infiltration of the tissues of the loin sometimes occurs, such that the clean-cut outline of the tumor is lost, its borders fading off into the surrounding structures. The skin of the flank may even be edematous; in such cases operation is hopeless. On the other hand, mobility of the tumor, notably soft sarcomata and hypernephromata, does not prove that the growth is still confined within the kidney capsule, or that it has not penetrated other structures, since the tumor tissue is so soft that the main body of the growth may be moved, though in places it may be attached to and infiltrate neighboring parts; moreover, such infiltration may occur into movable organs—the colon, for example.

Involvement and Thrombosis of the Renal Vein and of the Vena Cava.—Involvement and thrombosis of the renal vein and of the vena cava

can rarely be diagnosticated before operation, since both may exist without signs or symptoms. In the presence of a large varicocele upon the left side, developed with the growth of the tumor, thrombosis of the left renal vein is probable. Edema of the lower extremities and evidences of thrombosis, or enlargement of the veins of the lower extremity, or prominence of the veins of the abdominal wall, would indicate thrombosis of the vena cava, but such may, as stated, exist and produce no symptoms. If such symptoms are present operation is almost entirely hopeless.

Recognition of Metastatic Tumors.—As stated, metastatic hypernephromata may produce symptoms before the original growth is palpable, and the same may be true, though more rarely, of sarcomata. A careful examination of the bones for swellings and tender or painful points is desirable. In true cancers there is no means of knowing except by inference whether the neighboring lymph nodes are infected or not. Supraclavicular enlargements in advanced carcinoma of the kidney are conclusive.

Exploratory Incision.—In case we find no tumor of the kidney region by palpation, and yet other signs and symptoms exist pointing to such a tumor—hematuria, etc.—or to some other serious lesion of the kidney, we are entirely justified, with proper technic, in exploring the kidney by an incision in the loin. In case we are not certain which kidney is involved we are justified in examining both, through incisions in either loin, a much more certain method than palpation of both kidneys through a small cut in the abdominal wall in front. Some surgeons, notably the Mayo brothers, in the presence of any serious lesion of a kidney, when in doubt as to the exact condition of the supposedly sound organ, expose it first, and if it be found in a satisfactory condition replace it, close the wound, and remove the diseased kidney by a second incision. The several methods of determining the condition of the other kidney, as already described, are also useful in tumors, but, since the outcome of malignant tumors of the kidney is certain death unless nephrectomy be done, we are justified in taking more chances than is the case in most other conditions.

Cysts of the Kidney.—Aside from the cystic degeneration and the cystlike cavities found in some malignant tumors (due to hemorrhage, as described), cysts of the kidney may be divided into three groups: (1) Parasitic cysts (echinococcus). (2) Polycystic degeneration of the kidney. (3) Solitary cysts of the kidney.

1. Echinococcus Cyst of the Kidney.—Echinococcus cyst of the kidney is rare, even in countries where the disease is of frequent occurrence. Statistics indicate that the kidney is the seat of the disease less often than the liver or the lungs. In 2,111 cases of echinococcus, the kidney was the seat in 115, or 5.44 per cent. As elsewhere, the growth of the cyst is slow, extending over a period of years. Usually no noteworthy symptoms appear until the tumor has reached a considerable size. There are no changes in the urine unless rupture into the renal pelvis takes place, when hooklets and minute daughter cysts may appear in the urine (Gerster). The diagnosis has very rarely been made

before operation. The physical signs are the presence of a globular tumor in the kidney region, which, owing to the tension of the sac, may feel like a solid growth. In some cases fluctuation has been felt. The vibratory thrill on percussion has seldom been recognized—twice in 30 cases (Henry Morris). The diagnosis of a solid tumor, hydronephrosis, and even of ovarian tumor, has been made. Suppuration may occur with the formation of perinephric abscess or peritonitis. Infection is more likely to take place after the cyst has ruptured into the renal pelvis. The impaction of a daughter cyst in the ureter may give rise to hydronephrosis.

2. Polycystic Kidney.—Polycystic kidney, or polycystic degeneration of the kidney, as it may be called when it occurs in adult life, is found as a congenital defect at birth or develops later in life, usually, also, as the result of a congenital defect. Sometimes, in the opinion of certain pathologists (Neuwerk, Hufschmidt, and von Kalden), as a true cystadenoma of the kidney.

Pathology.—The kidney is enlarged, sometimes enormously, so as to form a large abdominal tumor, causing in the congenital cases a serious obstacle to delivery during labor, or, in adults, filling half the abdominal cavity. The general shape of the kidney is preserved. The entire kidney is converted into a mass of thin-walled cysts in which a variable amount of normal parenchyma remains. The cysts vary in size from microscopic spaces to globular bodies as large as buckshot or plums or small oranges. The contents of the cysts are clear yellow, or brown, or green, or bloody fluid, sometimes colloid material. The fluid is often turbid. Sometimes the fluid contains the constituents of urine much diluted, sometimes merely water, albumin, and salts, sometimes the decomposition products of blood. The pathology and genesis of polycystic kidney has been much studied, much disputed over by different observers, and, although not yet entirely clear, it appears probable that at least two forms of polycystic kidney exist which, though similar in gross appearances, really differ in finer structure and in origin.

The *first form* appears to be a congenital defect of development in the kidney, which may be well marked at birth, or, in certain cases, produce no change in the function of the organ until adult life. The condition has been associated with other congenital defects, and notably with the formation of cysts of the liver—nineteen per cent of the cases. The process consists of a hyperplasia of the connective tissue of the kidney (most marked in the pyramids, less so in the medullary substance), such that the caliber of the renal tubules is constricted, and finally closed with the formation of retention cysts in the glomeruli and tubules of the cortex. The condition has sometimes been associated with total atresia of the ureter. This form was characterized by Depage as *cystic sclerosis* of the kidney. The *second form*, it would seem probable, is a true cystadenoma of the kidney, occurring during adult life, but whether as the result of a congenital defect or in a previously normal organ is not certain. The views of pathologists are somewhat at variance as

to the exact genesis of this type; practically the matter is of no importance to the surgeon.

Clinical Importance of Polycystic Kidney.—Clinically the congenitally polycystic kidney has no great interest for the surgeon, since it is usually bilateral, and nearly all the infants die speedily. Only rarely one kidney is affected. The kidney presents itself as a considerable abdominal tumor with a knobby surface, and is scarcely to be distinguished on palpation from a solid growth. The polycystic kidneys which occur during adult life are of interest chiefly because when recognized before operation they are, speaking generally, better let alone. As in the congenital form the disease is usually bilateral—ninety-eight per cent of the cases (Bevan)—and appears to be hereditary to a certain extent; that is to say, it has been observed in several members of the same family. Sometimes but one kidney appears to be affected, but it usually happens that the other sooner or later undergoes the same change.

Operative Results.—There are, however, a few cases of unilateral disease that have remained well after nephrectomy for a number of years. Thus, among 5 cases of polycystic kidney among adults treated in the Roosevelt Hospital, 1 remained well after nephrectomy for six years, when he was lost sight of. One died within two years of disease of the other kidney. One died as the result of an exploratory operation, the disease being bilateral. One left the hospital well, but was lost sight of. One continued to suffer from pain and hematuria, indicating that the remaining kidney was also diseased; he was lost sight of at the end of a year. Israel had 4 cases, all bilateral and associated with cysts of the liver. Numerous operators have removed these kidneys successfully; but few cases, however, have failed to develop cystic degeneration in the remaining kidney sooner or later. Anchoring the kidney after evacuation of numerous cysts has relieved a certain number of patients (Curtis, Kammerer, Lund), at least for several years. If one kidney only is involved, nephrectomy is justifiable for the control of dangerous hematuria, suppuration, and unbearable pain.

Diagnosis of Polycystic Kidney.—The diagnosis of polycystic kidney is by no means easy. The symptoms and signs are usually simply those of a very slowly growing tumor of the kidney, associated with attacks of renal pain and hematuria. Among 78 cases collected by Ritchie hematuria was observed in 16; 20 had pain in the loins and abdomen. In some cases the kidneys have been observed to increase markedly in size during the attacks of pain, perhaps due to hemorrhage into the cysts. The disease, like malignant tumors of the kidney in adults, rarely develops marked symptoms until after the fortieth year; a few cases have been observed in young people. The average age of the patients when they die is about forty-five years. The duration of the symptoms varies greatly—from a few months to twenty years. Death usually occurs from uremia or from cerebral apoplexy. If both kidneys are involved the symptoms closely resemble those of chronic diffuse nephritis of the interstitial type (atrophic nephritis): Polyuria, low specific gravity, a trace of albumin,

urea normal, or lowered in amount, sometimes a few casts, sometimes pus, usually a little blood; hypertrophy of the left ventricle of the heart, a high-tension pulse, and arteriosclerosis. If under such conditions the patient has attacks of renal pain and hematuria we should think of polycystic kidneys. If both kidneys were palpably enlarged, and still showed passive and respiratory mobility, and if, in addition, cystic knobs could be felt on the anterior surface of the liver, the diagnosis would be almost certain. As is the case with hypernephroma, the appearance of hematuria may long antedate the presence of a palpable enlargement of the kidney. Assuming that but one kidney is enlarged, it is possible that in a slender person palpation by a very skillful surgeon might permit him to feel the nodular surface of a cystic kidney, and to recognize it as such; but it is to be borne in mind that malignant tumors may have much the same surface. The diagnosis has been correctly made a few times only—four times by Israel and one each by Lauenstein, Dugut, Verneuil, and Stiller.

3. Solitary Cysts of the Kidney.—Solitary cysts of the kidney are quite rare; they occur only in adult life, and are believed to be retention cysts of the glomeruli. They are formed in the cortex of the kidney, and, if small, are covered by a thin layer of cortical substance. They are most apt to develop at one or other pole or on the convex border than elsewhere. Although described as solitary, several cysts may occur in different parts of the organ; they are never grouped; four to ten have been observed. The remainder of the kidney remains normal. The contents of such cysts are a watery albuminous fluid, not urine. Hemorrhage into the cyst cavity may change the character of the fluid. Cysts containing colloid material have been observed. The size of the cysts varies. One or more cysts the size of an olive or larger are sometimes observed in the kidneys of elderly persons at autopsy, having given no symptoms during life. Minute cysts may occur in cases of interstitial nephritis, and larger ones may be due to the absorption of an old embolic infarct or to the remains of a hematoma of the kidney. In the retention cysts under consideration the cavity may slowly increase in size, and finally form a considerable, or even a very large, tumor. In two cases operated upon at Roosevelt Hospital, in one the cyst contained two pints of fluid; in the other the cyst was discovered while operating for a movable kidney. This cyst had developed from the posterior surface of the organ; it contained about four ounces of fluid. Cysts of this kind have been observed large enough to nearly fill the abdominal cavity. Israel and Henry Morris each describe a case in which a large cyst communicated with the renal pelvis.

Symptoms.—The symptoms produced are purely due to mechanical causes. The urine remains normal. In one of Dr. McBurney's cases at Roosevelt Hospital, the patient, a woman aged forty, complained that she had suffered a continuous, dull, aching pain in her right loin, more severe at intervals, for six years. There was a rounded, smooth, elastic tumor in the right flank, movable, projecting well below the ribs, extending nearly to the median line

in front. It would scarcely be possible to differentiate such a cyst fron hydronephrosis before operation, except, as Israel suggests, by catheterizat of the ureter of the affected side, and puncture and aspiration of the c The differences in the character of the two fluids might render the diagn of a cyst of the kidney probable. The procedure might be hazardous. If cyst becomes very large, disturbances of general health from pressure v occur, as in any large abdominal tumor.

4. Pararenal Cysts.—Pararenal cysts of unknown origin have been served in the vicinity of the kidney. Whether or not they depend for th origin upon vestiges of the mesonephros is not certainly known. Clinica they have been diagnosticated, if at all, as hydronephrosis.

CHAPTER XX

ANEURISM OF THE RENAL ARTERY—DISEASES OF THE ADRENALS—SYPHILIS OF THE KIDNEY

ANEURISMS OF THE RENAL ARTERY

A SMALL number of aneurisms of the renal artery or of one of its branches, either before entering the kidney or in the kidney substance, have been observed. Keen collected 13 cases, including 1 of his own. Henry Morris, in 1900, collected 19 cases, including those of Keen's list, a case of his own, 1 of E. Hahn, and 1 of Hochenegg's. Few, if any, have been reported since; though the traumatic variety, occurring immediately after an injury to the loin with the production of an arterial hematoma in, or in the vicinity of the kidney might be supposed, on *a priori* grounds, not to be exceedingly rare conditions. Among the 19 cases collected by Morris, 12 were traumatic and 7 spontaneous. Two of the traumatic cases were sacciform; they were discovered after death. Nine were arterial hematomata (so-called false aneurisms). One was doubtful. Two of these 9 resulted from the bursting of sacciform aneurisms. Of the 7 spontaneous aneurisms, 3 were sacciform, 1 was the size of an apple, 1 the size of a hazelnut, 1 the size of a haricot bean. The most common characteristics of the traumatic cases have been the history of an injury to the loin, either recent or remote; the occurrence of hematuria; the formation of an abdominal tumor, and pain in the kidney region—i. e., renal colic, in some cases absent, in others of agonizing severity. In none of the cases have the characteristic signs of aneurism been present, the reason being that when a tumor mass has been formed, it is deep-seated, and has nearly always been an arterial hematoma, in which here, as in other situations, many of the signs of aneurism are not distinguishable. Keen considered that the absence of pulsation and of the other signs of aneurism was probably due to the fact that the size of the artery was relatively small, as compared with the size of the tumor. In several cases the aneurism has been entirely within the kidney capsule and renal pelvis, a hematonephrosis, in fact. In only one case, that of Daniel Niebel, has pulsation been distinctly recognized, and the diagnosis of aneurism made. In two others pulsation was faintly perceptible and aneurism suspected. The spontaneous aneurisms have been small and have given no symptoms until they burst. The ruptures of the spontaneous and traumatic cases have occurred into the peritoneal cavity with immediately fatal results or the production of fatal

peritonitis; or into the retroperitoneal tissues with the production of a tumor in the abdomen and loin; or into the renal pelvis with profuse hematuria, often fatal.

Signs and Symptoms Separately Considered.—*Tumor Formation.*—Some of the arterial hematomata have given rise to large tumors in the kidney region and belly. In 14 out of the 19 recorded cases a tumor was detected during life. In several the tumor was developed in a few hours or a day or two. In others the mass has increased in size very slowly for weeks or months. In some of the cases the tumor was not formed until long after an injury to the loin, the explanation being probably that a small sacciform aneurism was first formed, which finally ruptured. The tumor has, as a rule, been of rounded contour and fixed, of firm or elastic consistence, sometimes tender, sometimes not.

Pain.—In those cases which have formed within the kidney capsule or have ruptured into the renal pelvis, agonizing pain or renal colic have been marked symptoms. In other cases when the tumor formed outside the kidney, severe pain has been absent, or has only occurred when the tumor reached such a size as to press upon the spinal nerves.

Hematuria.—Blood in the urine has usually been a marked symptom in aneurism of the renal artery or its branches. It has commonly been observed before the formation of a tumor. In the slowly progressive cases bloody urine has been observed immediately after the traumatism, and has ceased, to be followed sooner or later by the formation of a tumor; or the bleeding may have been almost continuous or intermittent, and so on, until the death of the patient; or it may have ceased entirely. In Keen's case a tumor was observed long before a single slight attack of hematuria. An arterial hematoma within the kidney may rupture into the renal pelvis and bleed the patient to death in a very short time. In a few cases the aneurismal tumor lying outside the kidney has ruptured into the renal pelvis with similar results.

Pulsation.—As noted, pulsation is a rare sign. *Bruit.*—In one case, that of Henry Morris, a loud systolic murmur was heard over the tumor; there was no thrill. In the other cases no murmur or thrill have been observed. It is to be borne in mind that any very vascular tumor may pulsate and exhibit a systolic murmur.

The Urine.—Except for the presence of blood in the urine, or of pus from infection and suppuration of an aneurismal sac connected with the renal pelvis or calyces, the urine is likely to be normal.

General Symptoms.—Anemia, loss of flesh and strength and disturbances of digestion, etc., from pressure, are the general symptoms likely to be noted in the absence of infection. For the history of a case of rupture of a branch of the renal artery, from injury to the loin, with the production of an arterial hematoma in the parenchyma of the kidney, intermittent hematuria, finally fatal, in spite of nephrectomy—see Subcutaneous Injuries of the Kidneys.

Diagnosis of Aneurism of the Renal Artery.—The small sacciform aneurisms of the renal artery produce no symptoms and are, therefore, not objects of diag-

nostic study. Following a history of injury to the loin, the occurrence of hematuria, notably if it has followed the injury immediately and has ceased and has become intermittent, would lead us to examine the kidney region. If a tumor was found, aneurism would be one of the possibilities, and we should operate upon such a case with due care, having such a possibility in view. The tumor following rupture of the kidney forms at once or in the course of a few days, is diffuse, etc. (See Subcutaneous Injuries of the Kidney.) If the injury to the kidney has not ruptured the capsule, and has led to the formation of an arterial hematoma within the parenchyma, with destruction of the kidney tissue by the mechanical action of the arterial blood pressure and distention of the calyces and pelvis (hematonephrosis), the tumor will have the general shape of the kidney; will be formed in hours or days; will be attended by agonizing pain, and by profuse hematuria in most cases. Seldom, if ever, unless the ureter be plugged, or crushed, or torn in two, or unless the renal pelvis is extensively torn or completely ruptured, will the urine be normal. If the patient survives, infection, sepsis, pyuria, and a pyohematonephrosis will be found at operation. It will be impossible in cases first seen at a late period to exclude a malignant tumor of the kidney. (W. W. Keen, *Philadelphia Medical Journal*, 1900; Henry Morris, "Surgical Diseases of the Kidney and Ureter," 1901.)

SURGICAL DISEASES OF THE ADRENAL BODIES

(*Suprarenal Capsules*)

Although the adrenal bodies are known to be organs whose physiological function is most important, and, although their destruction by disease in man, or removal by operation in animals, is followed by death, they have not, on account of their inaccessible position and the impossibility of differentiating tumors arising in them from tumors of the kidney, been the direct object of surgical operation, except in a very few cases. Twice the tuberculous adrenal gland (Addison's disease) has been extirpated successfully: once by Hadra, once by Jonas. Helferich also removed all or nearly all of a tuberculous adrenal. In all three cases the patients survived and were relieved from their symptoms. In Jonas's case the bronzing of the skin, characteristic of Addison's disease, faded in ten days, and was gone in three weeks. In a personal communication, Dr. John Thacher informs me that he performed an autopsy on the body of a man who died with septic symptoms. The probable diagnosis of an abscess beneath the right lobe of the liver had been made before death. There was an acute abscess above the right kidney, which had destroyed and appeared to have originated in the right suprarenal body.

Tumors of the Adrenals.—Although a variety of tumors occur in the adrenals, it is impossible to distinguish them from tumors of the upper end of the kidney, and usually in removing the tumor (most often an embryonal

adeno-sarcoma) the kidney has, from necessity, been removed also. Indeed, the surgeon can rarely tell until kidney and tumor have been removed together which organ has given rise to the new growth, and not always even then. *Benign tumors* of the adrenals of various kinds occur, though rarely. They have never been objects of direct surgical attack, and have usually been discovered by accident at autopsy or when operating on the kidney itself. Only in a few cases have *malignant tumors*, other than the embryonal sarcomata of infants, been demonstrated as certainly primary in the adrenals. The list includes sarcoma, malignant adenoma, and carcinoma. Owing to the very early involvement of surrounding structures—diaphragm, pleura, kidney, and upon the right side, vena cava; and the early formation of metastases in the liver—these operations have led to no good result. Owing to the position of the gland, a tumor arising therefrom will very rarely be palpable until it is beyond hope of radical cure by operation. There are no diagnostic data which permit a differentiation of such tumors from tumors of the kidney.

SYPHILIS OF THE KIDNEY

Either acquired or congenital syphilis may produce lesions of the kidney. Acquired syphilis may appear in the kidney in the form of: (1) Gummata; (2) acute or chronic diffuse nephritis; (3) amyloid degeneration of the kidney.

The gummata only are of direct surgical interest, and that but rarely. The gummata may form in any portion of the organ. They possess the same gross appearance on section here as elsewhere—a softened center of gummy material, surrounded by a layer of small round cells, and an area inclosing those of round-celled infiltration and fatty degeneration of the renal epithelium. When such gummata reach a considerable size they may be mistaken for true tumors of the kidney. A syphilitic history, and associated lesions of the liver and spleen, are among the diagnostic data. In a few cases such gummata have broken through the capsules of the kidney, invaded the surrounding soft parts, and caused an apparently cold abscess of the loin, with perforation of the skin and sinuses. The differential diagnosis from tuberculosis is not easy from the gross appearances.

The acute and chronic diffuse nephritis of syphilis does not differ materially in its symptoms from the ordinary forms of Bright's disease. It is important to bear in mind that though these cases must be treated with mercury and iodid of potassium, the mercury must be given with great caution.

CHAPTER XXI

INJURIES AND DISEASES OF THE URETER

(For the Topographical Anatomy of the Ureter, see Anatomical Remarks on Kidney and Ureter.)

INJURIES OF THE URETER

Injuries of the ureter may be divided into: (1) Accidental subcutaneous injuries. (2) Incised, punctured, and gunshot wounds. (3) Injuries produced by surgeons during operations upon the pelvic viscera. (4) Injuries occurring during labor.

1. **Subcutaneous Injuries of the Ureters.**—Subcutaneous injuries of the ureters as the result of blunt external violence are extremely rare; they have occurred from crushing injuries and falls, and especially in cases where the body has been severely compressed—as in run-over accidents, or where the body has been squeezed between the edge of a platform and a moving railway train. The mechanism of the injury is not entirely clear. Rupture of the ureter has been referred to a sudden pushing or dragging downward of the kidney, whereby the more fixed ureter is torn across just at its beginning, opposite the lower border of the kidney. It has also been supposed that the kidney was displaced in such a manner that the ureter was put upon the stretch or crushed and ruptured across the transverse process of one of the lumbar vertebræ; certain it is that, in three of the cases where the nature of the injury has been verified, the rupture has occurred just at the junction of the ureter with the renal pelvis, a point corresponding with the level of the tip of the transverse process of the third lumbar vertebra or a little above that point. Other causes in supposed rupture of the ureter have been the kick of a horse upon the abdomen, falling downstairs, falling and striking the loin against the rim of a wheel, falling on the back from a height, a violent strain in jumping from a horse. The number of cases in which rupture of the ureter has actually been verified to the exclusion of rupture of the renal pelvis or kidney is very small. Morris collected 24 cases from surgical literature, and studied the histories carefully. He concluded that only 3 were beyond peradventure actual ruptures of the ureter; while 12, though injuries of the ureter proper, were either contusions or partial tears leading to contractions or obliteration of the ureteral caliber.

PATHOLOGY.—In the 3 cases reported, in 1 (Poland's) the ureter was torn completely in two at the junction of the renal pelvis and ureter. In another (Mackenzie's) there were two small holes in the ureter, both communicating with the peritoneal cavity. In Morris's case the renal pelvis was opened, and the ureter, as discovered ten years later when the kidney was removed, was torn across at its junction with the pelvis; the lumen of the upper end of the lower fragment was obliterated. The pathology of the other cases is conjectural; doubtless in many there were associated injuries of the kidney, renal pelvis, peritoneum, and other structures.

SYMPTOMS OF SUBCUTANEOUS INJURIES OF THE URETERS.—The history of an injury to abdomen or loin, shock, pain, tenderness, and rigidity are, of course, present after any severe traumatism of the belly; nor do there appear to be any early characteristic signs or symptoms upon which a diagnosis of rupture of the ureter may be based; indeed, in several of the cases the early symptoms have been slight or indefinite. We shall discuss the several signs and symptoms observed in the recorded cases; the details are taken from the data collected by Henry Morris.

The Urine, Hematuria.—After the accident hematuria may be absent, slight, or fairly marked. The injured ureter itself bleeds but little, and the fact of its complete rupture would prevent the passage of much blood from the kidney were that also injured. In crushes of the ureter its caliber might well be obliterated at once. If the tear be incomplete, there may be no interference with the flow of urine and its quantity may be normal. If the kidney is also injured, or the ureter torn completely across, the amount of urine passed will be diminished from the first; there may be complete anuria for hours or days.

Pain.—In some of the cases there has been little or no pain in the loin until extravasation of urine and infection have caused an inflammatory tumor. In other cases the pain has simply been such as accompanies any severe contusion of the abdomen.

Tumor Formation.—If the patient survives the immediate effects of the injury several events are possible. If the rupture is intraperitoneal the escape of blood and urine into the peritoneal cavity will be followed by diffuse or localized purulent peritonitis, though before its occurrence signs of free fluid in the abdomen may be present. Extraperitoneal ruptures are followed by the escape of blood and urine into the retroperitoneal tissues and the formation of a tumor in the loin, which sooner or later causes cellulitis, suppuration and sloughing, often with putrid decomposition of the surrounding tissues. Aspiration of such a tumor would show the presence of urine, or urine and blood, or later of urine mixed with stinking pus. In some cases such a tumor has formed within a day or two, in others only after many days or several weeks. In the latter cases the ureter has probably been severely contused, and has finally sloughed. In a few cases stricture and final occlusion of the ureter has resulted, with the production of hydronephrosis; in Fenger's case, not until ten years had elapsed.

To sum up, the *signs and symptoms rendering rupture of the ureter probable*, we may say: The quantity of urine passed after the accident has been notably diminished and has contained a little blood or none, according to whether the ureter has been completely torn across, or partly torn, or crushed, and subsequently perforated. Severe septic symptoms, and the formation of a retroperitoneal tumor containing urine and blood, will be delayed for a longer or shorter time. Finally, no certain diagnosis is possible without operation.

2. **Incised, Punctured, and Gunshot Wounds of the Ureter.**—Open wounds of the ureter are so rare that there are but five recorded cases—two gunshot wounds and three punctured or incised wounds. Doubtless the ureter must have been cut by bullets many times in battle, the associated injuries having been so severe that the patients have not come under treatment. The signs and symptoms, assuming that the injury was uncomplicated, which would attract attention, would be the escape of urine from the wound or the formation of a tumor produced by urinary extravasation.

3. **Injuries Produced by Surgeons During Operations upon the Pelvic Viscera.**—Accidental wounds of the ureter in its intrapelvic portion are made during the removal of intrapelvic tumors, notably of the uterus. Such injuries are more apt to be made in the operation of vaginal hysterectomy for cancer of the cervix than in any other procedure. They may, also, occur in abdominal hysterectomy for the same disease, and during the removal of intraligamentous growths; occasionally in the removal of adherent pelvic tumors of any sort; and more rarely in operations for cancer of the rectum in women when the tumor has been rather high up. The injuries may be cuts—longitudinal, oblique, or transverse—and may or may not involve complete division of the ureter. The ureter may be accidentally caught in the bite of an artery forceps and crushed. The ureter may be included in a ligature in tying off the uterine artery, where it passes behind the ureter to ascend along the lateral aspect of the uterus between the layers of the broad ligament, the point of crossing being at the level of the internal os, distant 1.5 cm. from the uterus.

In the operation of *vaginal hysterectomy* the ureter may be included in the ligature passed through the broad ligament, or, though not included, so compressed as to be occluded or even caused to slough from interference with its blood supply. This method of operating should be avoided in all cases where the broad ligaments are infiltrated either with cancerous or inflammatory material. The free mobility of the uterus should be determined by bimanual palpation and, if necessary, by traction upon the cervix with volsellum forceps; and during the operation the bladder and ureters must be carefully separated from the uterus, using the finger or closed blunt scissors for the dissection. Clamps with long jaws should be avoided. The uterine vessels should be clamped close to the cervix. In *abdominal hysterectomy for cancer* the ureter may be buried in cancerous or inflammatory infiltration. A useful device (Kelly) is the introduction of catheters into both ureters *before begin-*

ning the operation. At the end of an operation the passage of the catheter may be more difficult and may delay the operation at a time when speed is desirable. They serve as guides, and sometimes permit the surgeon to dissect out and free a ureter which might otherwise have been crushed or tied off.

In cases of *intraligamentous growths* and in some *fibroids* and *ovarian tumors* the ureter may be displaced, so that it runs along the brim of the pelvis. In other cases the bladder may be greatly displaced upward by a tumor growing between it and the uterus, so that the ureter may be pushed upward as high as the umbilicus. Blumenfeld showed that a tumor growing upon one side may displace the uterus and bladder, and with them the ureter of that side, across the median line to the opposite side of the pelvis, and that if the uterus and bladder become adherent to a tumor, it, by its further growth, may drag them both across the median line, and with them the ureter of the opposite side; or, if the tumor grows between the uterus and bladder, the ureter may become adherent to it, and rise with its growth entirely out of the pelvis. Before beginning the extirpation of fibroids or of intraligamentous tumors or solid tumors of the ovary, or in any case where the normal relations of the pelvic viscera are altered by the growth, it is always wise to look for and try to identify the ureters.

I recall a recent case of fibromyomata of the uterus in which one of the tumors grew between the uterus and bladder; the left ureter was displaced upward and outward, so that it passed along the brim of the pelvis and lay upon the ovarian vessels. I passed the aneurism needle beneath the vessels and ureter, but the ureter looked thick and white, and felt firmer than a vein should feel and did not pulsate, so I did not tie the ligature. Further examination enabled me to trace the white cord around the tumor to the bladder, and thus identify it. I once included the ureter in the ligation of the uterine artery in a case of uterine cancer, but recognized the error, cut the ligature, and no harm befell the patient. I have never cut the ureter by accident, but excised a portion intentionally in a case of cancer of the uterus, which did not permit a clean dissection of the ureter. I made an anastomosis between the divided ends, but there was too much tension; the ureter sloughed at the end of a week; urine escaped through the vagina; and I removed the kidney two days later. The patient survived.

After the completion of all difficult pelvic operations the ureters should be examined to see that they are not injured. In spite of all precautions the ureter is sometimes torn, ligated, or cut by good surgeons of large experience. In difficult pelvic cases the difficulty of working without the guidance of the eye, the separation of dense, firm adhesions with scissors, the necessity of quickly controlling hemorrhage—all render such an accident at times unavoidable. It is usually possible to recognize the injury at the time, and take the necessary steps for its repair and for the safety of the patient. Sometimes the ureter is crushed by a clamp or tied or occluded by a ligature which does not actually surround it. In such cases the surgeon may not be aware

of what he has done; this is, of course, more often the case when operating by the vaginal route; the ureter may then, after a time, slough, or even burst above a ligature. If the ureter is simply cut urine will escape through the vagina immediately after the operation, or if no such outlet is present—as after the removal of a tumor not involving vaginal drainage—the patient will pass a small amount of urine, and will develop an accumulation of urine in the peritoneum, resulting, if not recognized very early, in a diffuse peritonitis or in a localized peritonitis with abscess. If the abdominal wound has been drained, urine will appear in the abdominal dressings. If the ureter sloughs at a later period the escape of urine, or other symptoms, as above, may not occur for a week or more after the operation. Absolute closure of the ureter by ligature will result in dilatation of the ureter, possibly in a moderate hydronephrosis or atrophy of the kidney; usually the ureter sloughs at the point of ligature, and urine escapes from the vagina. Ligature of both ureters would be followed, of course, by anuria, and this condition would lead the surgeon to reopen the abdomen and liberate the ureters; this has been done successfully.

4. **Injuries Occurring During Labor.**—The cases of injury of the ureters during labor or instrumental delivery result in ureterovaginal or in ureterouterine fistulæ.

Diagnosis of Ureteral Fistula.—The diagnosis of ureteral fistula is not difficult. Urine escapes from the vagina continuously, and the introduction of a speculum usually makes its source clear. If, however, the condition has lasted for some time, and the history is not entirely plain, the following facts may be used to exclude other varieties of urinary fistula. Congenital ureteral fistulæ in women are to be distinguished from those following trauma by the fact that the former have existed throughout life and that the abnormal opening of the ureter lies below the trigonum of the bladder, and may even empty through some part of the external genitals. The traumatic forms open at the base of the bladder, in the vault of the vagina, usually high up alongside the cervix. The orifice is embedded in scar tissue. The fistulæ following labor may empty into the uterus, in which case urine escapes from the cervix.

Differential Diagnosis.—Ureteral fistulæ are to be distinguished from *vesicovaginal fistulæ* by the following data: If the bladder be injected with a colored solution, the fluid escaping into the vagina from a vesicovaginal fistula will be stained; if the fistula is of the ureter, uncolored urine will continue to escape from the vagina. A patient with a vesicovaginal fistula dribbles urine constantly, and, unless the fistula be very small, does not have occasion to urinate in the normal way. A ureteral fistula also furnishes urine constantly while the patient continues to urinate at regular intervals. If a patient with a ureteral fistula sits on a vessel for a certain time the urine obtained should approximate in quantity that obtained by passing a catheter into the bladder, assuming that the bladder was empty when the test was commenced. In ureteral fistula if a ureteral catheter be passed into the

ureteral orifice of the affected side the catheter will be stopped after entering a short distance, and no urine will flow from it. A catheter passed into the fistula, on the other hand, will pass on up to the kidney, and from it urine will slowly and continuously flow.

THE DISEASES OF THE URETER

The pathological lesions affecting the ureter are usually so closely associated with disease of the kidney that the two conditions are best studied together; and we have described under the Diseases of the Kidney most of the important changes which occur in the ureter, and the symptoms referable thereto. There remain, however, certain aspects of the topic which demand separate consideration.

Ureteritis and Periureteritis.—Inflammation of the ureter very rarely occurs as an independent lesion; usually the ureter is merely the avenue whereby infections of the bladder ascend to the kidney, or *vice versa*. A peculiarity is often observed, notably in *acute* infectious processes—namely, that, whereas the pathological lesions produced in the kidney are of the most serious and destructive character, the changes in the ureter are very slight. The symptom-complex—as already described under Pyelonephritis—is partly that of sepsis, partly that due to the destructive lesion of the kidney, the only sign referable to the ureter being perhaps moderate tenderness on deep pressure where the ureter crosses the pelvic brim. In some cases vaginal or rectal examination will enable one to feel the ureter as a very tender cord passing from the vesical neck upward and backward. In chronic inflammations of the ureter, notably in tuberculosis, the ureter may be greatly thickened (see below).

We have described tuberculosis of the ureter under Renal Tuberculosis. Here may be added that, when removing a tuberculous kidney, it is well to remove as much as may be reached of the ureter; this is the more important when the ureter is extensively diseased; yet I have only seen one case where, after another surgeon had removed a tuberculous kidney, I was obliged to operate again on account of a persistent tuberculous sinus. The operation was difficult.

While, as stated, acute ascending or descending processes may produce but little change in the ureter, such is not the case in chronic infections. The ordinary pyogenic bacteria, the gonococcus, Bacillus tuberculosis, may all cause serious obstructive lesions, interfering with the passage of urine to the bladder, either by creating a mechanical obstacle or by interfering with the muscular activity of the walls of the canal. The ureter may be strictured, either by cicatricial contraction or by the formation of valvelike projections of its mucous membrane. The tube may be deformed and kinked in various ways—by dense infiltration of its coats with inflammatory tissue and by periureteral bands and adhesions to neighboring structures. Ulceration, notably in cases

of tuberculosis, may form pits and hummocks in the canal. The formation of papillary outgrowths is also a not uncommon event in chronic pyonephrosis. Some of these ureters become as large as a man's thumb, with walls a third of an inch thick, and feel as dense and hard as leather.

We have already described the marked deposition of fat which may occur in the wall of the ureter in cases of chronic inflammation of all kinds. (See Pyonephrosis.) Such ureters are palpable, either *per vaginam* or *per rectum*. They feel like firm cords, often nodular, notably if tuberculous; they are tender. In women they may be mistaken for a fixed ovary or for a pus tube or a pelvic exudate. If the individual is thin, and has relaxed abdominal walls, the ureter may sometimes be felt through the abdominal wall as a tender cylindrical body passing over the brim of the pelvis. In all these conditions there will usually be pyuria, sometimes hematuria. (See also Cystoscopy and Catheterization of the Ureters.) While, as already stated, these changes in the ureter usually form only an accompaniment to disease of the kidney, and are observed incidentally when operating on that organ, yet cases of independent inflammatory disease of the ureter alone with only trifling involvement of either the kidney or bladder have occasionally been observed.

Thus, Israel relates a case of a young man who had suffered from painful and frequent urination for eight years, accompanied by violent and frequently repeated attacks of renal colic. Hematuria of macroscopic quantity was noted from time to time. The urine always contained some blood cells and a variable quantity of catarrhal ingredients. There was extreme tenderness of the kidney and along the course of the ureter. The kidney was exposed, on the assumption that a stone would be found; the kidney appeared nearly normal and contained no stone. The symptoms not abating, the renal pelvis was opened and the ureter exposed. "The ureter was found to be extraordinarily hard, it was three times its normal thickness. At various points there were swollen sections as hard as cartilage. The ureter adhered firmly to the lateral wall of the pelvis." A bougie, size No. 10, French, could be passed into the bladder. The attacks of pain continuing, the kidney and a part of the ureter were extirpated. The pains ceased, and after a time the urine became normal. A second case of Israel's, "a membranous ureteritis," caused by a chronic bacteriuria is of interest. The patient, a young woman, passed masses of pus containing calcareous matter, usually in the shape of casts of the ureter; small calculi were also passed. The prominent symptoms were attacks of fever and of renal colic. Removal of the kidney cured the disease. The bladder having been always normal, the kidney showed the lesions of interstitial nephritis merely.

Periureteritis may also occur *secondarily* in any of the forms of chronic ureteritis with the production of inflammatory tissue around the ureter which may bind it firmly to the surrounding structures, and make the removal of the ureter extremely difficult or impracticable. In cases where the ureter has been cut during pelvic operations an ascending periureteritis has been observed.

Periureteritic Phlegmon.—Cases of periureteric phlegmon have been described in which the signs and symptoms seemed to point to ulceration and perforation of the ureter as a source of the infection. (See Stone in the Ureter.)

Stricture of the Ureter.—Stricture of the ureter may arise from any chronic inflammatory process of the walls of the canal, notably from gonorrhea, from external violence, as when the ureter is crushed without being ruptured, and from pressure ulceration of the ureter produced by the prolonged presence of stone in the canal. The interference with the outflow of urine causes hydroureter or pyoureter, and usually hydronephrosis or pyonephrosis as well; as stated elsewhere, sudden complete and permanent obstruction produces atrophy of the kidney.

Diagnosis of Stricture of the Ureter.—Diagnosis of stricture of the ureter can sometimes be definitely made, sometimes it cannot. The signs and symptoms will be those of hydronephrosis or pyonephrosis, according to whether infection is present or absent, or of nephrolithiasis, or of renal tuberculosis. The presence of strictures can only be ascertained by the introduction of ureteral bougies and catheters, which meet an obstruction after advancing a certain distance. Fallacies are here probable on account of folds of mucous membrane, ulcerations, and indurated areas, making the canal tortuous or rigid; or from the presence of stone in the ureter; or from *the outside pressure of any variety of pelvic tumor.* If the bougie can once be passed through the stricture the surgeon may feel it firmly gripped by the stricture upon withdrawal. If a fusiform or bulbous catheter is used this sensation will be more marked. The technic is described under Ureteral Catheterization. Although naturally more difficult in men than in women the procedure is, nevertheless, practicable in the latter. A further confirmation of the diagnosis has been obtained in certain cases by the steady escape of a considerable quantity of clear or purulent urine through the catheter after passing the stricture; and, further, by the ability to inject considerable quantities of fluid through the catheter into the dilated portion of the ureter above the stricture without causing pain. It is desirable to locate the position of the stricture. For this purpose the catheter should be introduced slowly; when the stricture is passed the urine begins to flow; the catheter may then be slowly withdrawn until the flow ceases; we then know that the eye of the catheter is within the stricture.

If the examination is made with the cystoscope, the length of it deducted from the total length of the catheter, from the point where it enters the extravesical end of the cystoscope, gives the depth of the stricture. In women any straight instrument introduced through the Kelly tube serves as a measure from the outer extremity of the tube to the ureteral orifice; this distance being deducted in a similar manner, gives the depth of the obstruction. Many strictures of the ureter are only discovered when the kidney is exposed in the loin, its pelvis opened, and a flexible bougie or sound introduced downward

to the bladder—a measure never to be neglected when the condition of the kidney is such that nephrectomy is not positively indicated.

Therapy of Stricture of the Ureter.—The therapy of stricture of the ureter varies with the underlying cause, and the situation of the stricture; it should be conservative if possible. A few strictures can be successfully dilated; in other cases a plastic operation on the canal itself is possible; in others, an anastomosis between the ureter and the renal pelvis; in others, implantation into the bladder; in others, nothing short of nephrectomy is indicated.

Ureteral Calculus.—The majority of ureteral calculi have descended from the kidney. (See Nephrolithiasis.) These calculi are prone to lodge at three points, slightly narrower than the remainder of the canal: (1) At the commencement of the ureter, opposite the lower border of the kidney. (2) About opposite the brim of the true pelvis, or a little lower. (3) In the vesical portion of the ureter—i. e., in the bladder wall. They sometimes remain impacted at the papilla, and may project into the bladder; they are then visible through the cystoscope. It is well to bear in mind that the calculi may be multiple. The changes produced in the kidney and ureter by calculi have been discussed under Nephrolithiasis. They are pyonephrosis, infected hydronephrosis, occasionally in noninfected cases, hydronephrosis.

The changes produced in the ureter by the prolonged impaction of a stone are partly due to obstruction of the flow of urine, partly to mechanical irritation, combined with infection.

The first causes dilatation of the ureter above the obstruction, to which may be added a tortuous course and increase in its length. The second causes swelling, and later ulceration of the ureter at the point of impaction, with the production of pyoureter, and of stricture of the ureter, or periureteritis with adhesions, sometimes perforation of the ureter, extravasation of urine, and a periureteric phlegmon. (See Periureteritis.)

In total occlusion of the ureter by a calculus, in a kidney not already dilated, atrophy of the kidney, occasionally complete and fatal anuria, either reflex or due to a crippled kidney upon the other side, may occur. Incomplete obstruction, noninfected and of long duration, may also produce total atrophy of the kidney.

Symptoms of Ureteral Calculus.—The symptoms of stone in the ureter resemble those of stone in the kidney, though the former are more often accompanied by renal colic than the latter. In some cases the symptoms will be referred to the lower part of the urinary tract to an extent not common in kidney stone. These patients will complain of intense vesical tenesmus, of pain in the glans penis of males, or in the labia and vestibule of females, or of painful urination, with normal frequency, of pain in the prostate and sacrum. In many instances the pain is referred distinctly to one side of the median line; still, these localizations are merely suggestive, not positive indications of ureteral stone. The changes in the urine are those described under Stone in the Kidney.

(For the *X-ray diagnosis* of ureteral calculi, see the X-rays.)

Examination for Stones in the Ureter.—Stones in the ureter may be felt by vaginal and rectal examination in women in many cases, and a smaller number by rectal palpation in men. General anesthesia permits a more complete examination. As elsewhere stated, the passage of a wax-coated bougie up the ureter and beyond the stone, enabled Kelly, by the scratch marks on the wax, to demonstrate the presence of calculus. The procedure has been carried out successfully by others. In women the passage of a metal ureteral probe may enable the surgeon to touch a stone and feel a grating sensation. A very large stone in a thin subject might be felt at the brim of the pelvis through the abdominal wall. The *X-rays*, though not infallible, remain the simplest and surest means of diagnosis.

Valve Formation in the Ureter.—As a cause of hydronephrosis, the formation of a valvelike projection of mucous membrane at the junction of the ureter with the renal pelvis has been observed in a number of instances. The causation of such valvelike projections is not always clear. They are sometimes congenital, sometimes the result of the sinking of a movable kidney. The symptoms and lesions are those of hydronephrosis. When operating upon hydronephrotic kidneys, such valvular projections should be sought for. If found, a plastic operation upon the ureter and pelvis may sometimes be done for their relief.

Kinking of the Ureter.—Another cause of hydronephrosis, and of the attacks of renal colic accompanying movable kidney, is angulation of the ureter at its junction with the renal pelvis, caused by the sinking of the movable kidney and the fixation of the upper portion of the ureter by normal or abnormal adhesions. The history of such a case will be found under the head of Intermittent Hydronephrosis. In this instance, elevation and fixation of the movable kidney in a nearly normal position sufficed to overcome the angulation and establish a free channel for the flow of urine. Since writing the above I have had another similar case. In some cases this will not suffice, and in such, separations of adhesions, suture of the ureter itself in some new position, or a plastic operation on the ureter, may be necessary to relieve the obstruction.

Cystic Disease of the Mucous Membrane of the Ureter.—The condition appears to be not very rare. Thirty-eight cases were collected from the literature by Otto Davidson in 1901. The disease may develop during infancy or later in life. Some of the cases are parasitic. In the cysts the coccidia of certain psorosperms have been observed. In other cases the cysts have contained clear mucus or colloid material and epithelial cells.

The cysts are scattered over the length of the ureter, and may be so numerous as to completely cover the mucous membrane. They may occur in the renal pelvis and trigonum of the bladder. The individual cysts vary in size from that of a millet seed to that of a pea. The main surgical interest of the condition lies in the fact that the disease has in some cases been attended by attacks resembling renal colic and by hematuria; and, further, that the walls of the ureter may be thickened and hard and its vesical orifice patent. Infection

from the bladder is thus favored. The disease is sometimes bilateral. If the cysts are present at the papilla or in the bladder, the cystoscope would be useful in diagnosis.

Prolapse of the Ureter into the Bladder.—Prolapse of the ureter into the bladder has been observed. In one case the surgeon mistook the prolapsed ureter for a tumor and cut it off. The patient died.

Cysts of the Ureter.—Solitary cysts of the vesical end of the ureter, of considerable size, projecting into the bladder, have been observed.

Congenital Diverticula.—Congenital diverticula of the lower end of the ureter have been reported in twenty cases. Obstruction and hydronephrosis have been the usual result.

Tumors of the Ureter.—A few benign and malignant tumors have been recorded as primary in the ureter. Albarran has collected the largest number of cases—42. In 18 the tumors were papillomata. In 1 they were observed projecting into the bladder. They had caused obstructive symptoms and hydronephrosis. The kidney and ureter were removed. The papillomata may be diffuse or limited to one or both ends of the ureter. They may recur after removal, and may undergo malignant degeneration.

Diagnosis.—The diagnosis must be based upon obstructive symptoms, sometimes hematuria, the cystoscopic examination, ureteral catheterization, catching and bringing away a fragment of tumor tissue, or upon the passage of a fragment of tumor tissue in the urine and its recognition under the microscope.

Sarcoma.—A very few cases of primary sarcoma of the ureter have been recorded.

Carcinoma.—Malignant epithelioma and carcinoma have been recorded in a few cases as primary in the ureter. Hematuria has nearly always been the first sign of the disease, the course of which is apt to be short. Gerstein reported a case of a primary cancerous nodule the size of a pigeon's egg, surrounding the mouth of the right ureter. The patient, a man of sixty-seven, died. Other nodules were found in the bladder and in the right kidney. Among the cases collected by Albarran, three were primary in the ureter.

The *signs and symptoms* of cancer of the ureter are hematuria, the formation of a tumor—i. e., a hydronephrosis. There may be steady pain or attacks of renal colic, or none.

Hematuria is a nearly constant symptom, otherwise the urine will be nearly or quite normal. Epithelia and possibly fragments of tumor tissue may appear in the urine, but a diagnosis can rarely be made on these findings. The cystoscope and ureteral catheter may aid in the diagnosis. The course of the disease is short, and no diagnosis of the exact condition is likely to be made until the kidney and ureter are exposed.

CHAPTER XXII

RENAL HEMATURIA

Conditions Attended by Hematuria.—Aside from the various diseases of the kidney described in the previous pages, accompanied more or less constantly by hematuria, there remain to be discussed a number of conditions attended by bleeding from the kidney, some of them amenable to surgical treatment, some of them not. They were formerly grouped under the general head of Essential Renal Hematuria because the pathology of the several forms was obscure, and while it cannot be denied that in a few cases bleeding from the kidney without any evident pathological lesion does occur, yet the number of such cases reported has greatly diminished *pari passu*, with a more complete knowledge of kidney pathology.

The conditions may be grouped under several heads:

1. *Hemophilia.*—A number of cases of renal hematuria have been observed among bleeders. The diagnosis is to be made from the personal and family history.

2. *Renal hematuria* from prolonged muscular effort, in persons otherwise healthy. Usually confined to a single attack.

3. *Hematuria* from movable kidney and in hydronephrosis. The former very rare. The latter very common. Both are probably due to mechanical interference with the circulation of the kidney or with obstruction of the ureter and intense venous congestion.

4. A few cases of hematuria occurring in *tabetics* have been reported without other evidences of kidney disease. A tabetic man who has been under my care for a number of years had a single sharp attack of hematuria about two years ago, coming on without pain and lasting twenty-four hours. A pint or more of blood was lost. The blood came from the right kidney, as shown by cystoscope. The kidney was neither enlarged nor tender. There have been no evidences of nephritis in the urine, nor has the attack been repeated.

5. Cases of *unilateral nephritis* accompanied by hematuria. In these cases other signs of nephritis may be wanting. Albuminuria may be present or absent. In some the urine will contain casts. The hematuria may or may not be accompanied by pain. The lesions in the affected kidney are circumscribed areas of sclerosis and of acute and chronic diffuse nephritis. The history of a young man whose kidney I removed in 1904 is interesting in this connection:

The patient, a young man aged twenty, denied venereal disease. One month before I saw him he was awakened at night by severe pain in the right loin, radiating downward to the bladder, groin, and testis. He desired to urinate and observed that his urine was bloody. The hematuria lasted two days. Since then he had had frequent and painful urination day and night and had observed blood in his urine at intervals of two or three days. He felt weak and ill, and was obliged to give up work. His urine, when examined, was acid. Specific gravity, 1.018. Dark amber. Cloudy. Moderate. Albuminuria. Microscopic. Much blood. Pus cells in moderate number. No tubercle bacilli.

Physical Examination.—A slender, rather delicate-looking young man. Decided tenderness over the region of the right kidney. Kidney not felt. Upon exposing the kidney it was of normal size. There were several depressed areas on the surface. Capsule split and found adherent. Surface of cortex granular. Incision into kidney showed areas of hemorrhage into parenchyma. Kidney removed.

Pathological Report.—The specimen is a kidney measuring $10 \times 4.5 \times 3$ cm. Capsule has been stripped away, leaving a slightly roughened surface in which are several cicatricial depressions, each a few millimeters in diameter. There are also a few areas of recent hemorrhages. The markings of the cortex are very indistinct. Sections show a diffuse nephritis, presenting a variety of changes, some chronic, some acute. Of the former, the most marked are a pronounced increase of fibrous stroma. Fibrous thickening of many capsules of Bowman. Atrophy of many glomeruli and hyaline degeneration of a few vessels. Acute inflammation is indicated by abundant infiltration with small mononuclear cells and many casts, chiefly hyaline, but a few contain leucocytes. Parenchymatous degeneration of cells is marked.

The patient recovered and has remained without signs of nephritis in the remaining kidney during five years.

6. *Cases of bilateral nephritis* in which but one kidney bleeds.

7. *Cases of a varicose condition* of the veins of the renal pelvis or ureter, or, in two cases (Fenwick), a varicose condition of the veins of a single papilla.

8. *Cases of doubtful character*, designated, for want of better names, *angioneurotic hematuria*, *hysterical hematuria*, and *nephralgia*. Some years ago I saw a middle-aged woman, well nourished, not neurotic, whose complaint was hematuria, coming on at irregular intervals without pain, lasting for hours or days. The quantity of blood in the urine was never large, but enough to give it a distinct tinge of red. Her right kidney was movable. I catheterized both ureters, and from both bloody urine was obtained. Exposure of the right kidney showed no abnormality except mobility of the second degree. The capsule was split and sutured to the muscles of the loin. Other attacks of hematuria occurred; the patient became discouraged, and was lost sight of.

Diagnosis.—In some cases of unilateral nephritis the attacks of hematuria and renal pain will be so marked that the surgeon will expose and examine the kidney in the expectation of finding a calculus, a tuberculous focus, or a tumor. With the exception of the lesions described, the findings will be negative. The mere splitting of the kidney has benefited, and even cured, some of these cases.

At present our knowledge of the pathology of the kidney is more accurate than it was a few years ago. It is believed that the cases formerly classed as angioneurotic hematuria, hysterical hematuria, and nephralgia have some real lesion as a cause. It is quite certain that hyperemia and congestion of the kidney, due to various causes, may, by producing increased tension within the kidney capsule, bring on attacks of kidney colic in no way to be differentiated from those caused by the passage of a stone down the ureter. Obstructive conditions to the flow of urine, such as may occur from a movable kidney with kinking or torsion of the ureter or from valve formation, may cause typical renal colic, and occasionally hematuria. In several cases firm adhesions have been found between the fatty and fibrous capsules of the kidney.

In a general way it may be said that, from the very nature of the lesions and symptoms, a large proportion of these cases cannot be distinguished from stone, tuberculosis, etc., without exposing and incising the kidney. In case nothing abnormal is found, a small piece of kidney tissue may be removed, when, if the process is diffuse, the microscope may clear up the diagnosis.

The pathology of these somewhat obscure cases was well summed up by James Israel, in conclusions drawn from his own experience and that of others. He wrote:

1. There are cases of unilateral nephritis.
2. Nephritis may be accompanied by renal pain identical in character with the attacks of renal colic accompanying obstructive lesions.
3. Bilateral nephritis of like severity in each kidney may give rise to purely unilateral pain and colic.
4. Nephritis may cause pain radiating to the bladder and urethra.
5. There may be a sévere nephritis with neither albumin nor casts.
6. The urine may contain large numbers of hyaline, granular, and epithelial casts and no albumin.
7. There are cases of nephritis accompanied by periodic or continuous bleeding which, as regards its severity and duration, the capriciousness of its occurrence, its limitation to single acts of urination, cannot be distinguished from the hematuria accompanying malignant tumors. Renal hematuria may begin and continue with or without renal colic. The bleeding is not the cause of the colic; both are consequences of the congestion of the kidney.
8. A large number of the conditions—formerly designated nephralgia, néphralgie hématurique, angioneurotic renal hematuria—are due to nephritis.
9. Incision of the kidney has a favorable influence on the symptoms in many of these cases.
10. The wound in the kidney should not be closed by suture.

PARASITIC DISEASES CAUSING HEMATURIA

In the tropics a number of parasitic diseases have hematuria as a symptom. Some of these diseases get well after a sojourn in a cold or temperate climate. Only a few such cases are seen in New York. Among these parasites

are Filaria sanguinis hominis. (For a description of the characters and life history of this nematode worm, see Elephantiasis of the Scrotum and Penis.)

Filariasis.—Filariasis has chyluria as a symptom in many cases. Hematuria may coexist or be present alone. The chylous urine, if allowed to stand, separates into three layers—an uppermost layer of fatty emulsion, a middle, nearly clear, layer of urine, and a bottom layer of blood.

Bilharz Disease—Endemic Hematuria of Egypt.—Another parasitic disease of the tropics attended by hematuria is known as *Bilharz disease*, or *endemic hematuria of Egypt*. It is caused by a trematode worm or fluke (Distoma hematobia Bilharzii). In Egypt, hematuria associated with the subsequent development of vesical calculus has long been known as a very frequent disease among native male children and young men. The cause was discovered by Professor Bilharz, of Cairo, in 1851. The sexes of the worm are separate. They are milk-white in color. The male is cylindrical in shape, 12 to 14 mm. long, 1 mm. broad. It has an oral and a ventral sucker, placed close together.

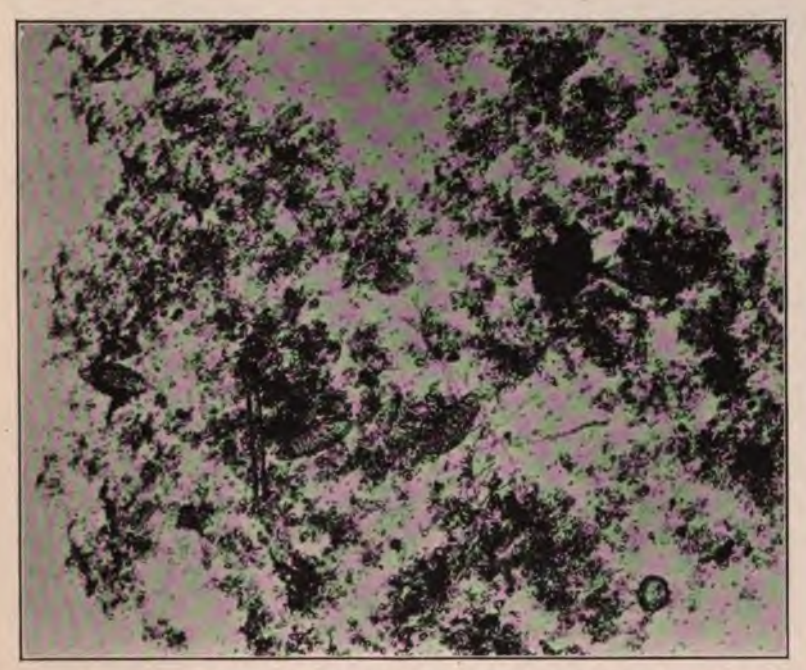


FIG. 130.—URINARY SEDIMENT IN DR. POOL'S CASE OF BILHARZ'S DISEASE. Low magnifying power showing ova, crystals, red cells and granular detritus.

The genital opening is just posterior to the ventral sucker. By a ventral infolding of the lateral borders of the worm there is created a gynecophoric canal for holding the female during coitus. The female is longer—14 to 19 mm.—than the male, the body is more slender, and during coitus projects beyond his body at either end. The ova are ovoid in shape; they are 0.12 mm. long and 0.04 mm. wide. They are inclosed in a transparent envelope or shell,

and possess a spine, usually placed at one end, sometimes laterally. Within the ovum lies the embryo. This may be liberated under the microscope by pressure upon the cover-glass. When the shell has burst and the embryo escapes, it is seen to be an actively motile organism with many cilia. It is ovoid

Fig. 131.—Ovum of Distoma Hematobia. Magnified 500 diameters. (Dr. Pool's case.)

in shape, more blunt at the head end. When swimming it becomes more elongated. The embryos die in urine after twenty-four hours, but may be kept alive in water for several days. The life history of the embryo is not known, nor what its intermediate host may be, nor whether they enter the human body with such a host or alone.

Occurrence.—The disease is most common on the Nile, and is here very common, affecting a very large proportion of the population—42 times in 92 autopsies (Sonsino). It also occurs in many other parts of Africa and in Syria, Cyprus, Madagascar, India, and other tropical countries of the East.

The cases observed in the United States are chiefly imported, a few doubtful cases only having apparently developed in Indiana and Illinois.

Mode of Infection.—The mode of infection is either through impure drinking water or through bathing, or both. Whether the embryos are swallowed in an encysted state, or whether they enter through the skin or through the urethra, is not certainly known. The first mode seems the most probable one.

Pathology.—The chief lesions of the disease are found in the genito-urinary tract, the bladder being most often affected. The adult worms are found in the branches of the portal system of veins; most often in the veins of the bladder and rectum; very rarely free in the genito-urinary tract. In the smaller veins the female deposits her ova. These finally perforate into the surrounding

tissues, giving rise to irritative and inflammatory changes, or into the genito-urinary tract or rectum, causing hematuria, or the passage of blood *per rectum*. The ova may then be found in the urine or feces, as the case may be, in large numbers. As stated, the bladder is the most frequent seat of the perforations. They may be viewed through the cystoscope, and appear, according to O'Neil,[1] "as congested and ecchymosed patches, varying in size from one fourth to half an inch in diameter, covered with mucus containing many ova. They are generally in the posterior part of the bladder." Later in the disease, more fully developed lesions may consist of vegetations, and considerable tumor masses coated with earthy salts. The searcher in the bladder, grating upon these, gives the sensation of stone. In addition, the wall of the bladder may be thickened and its capacity reduced. The outgrowths may entirely fill the bladder. Similar lesions may be developed in the ureter and renal pelvis.

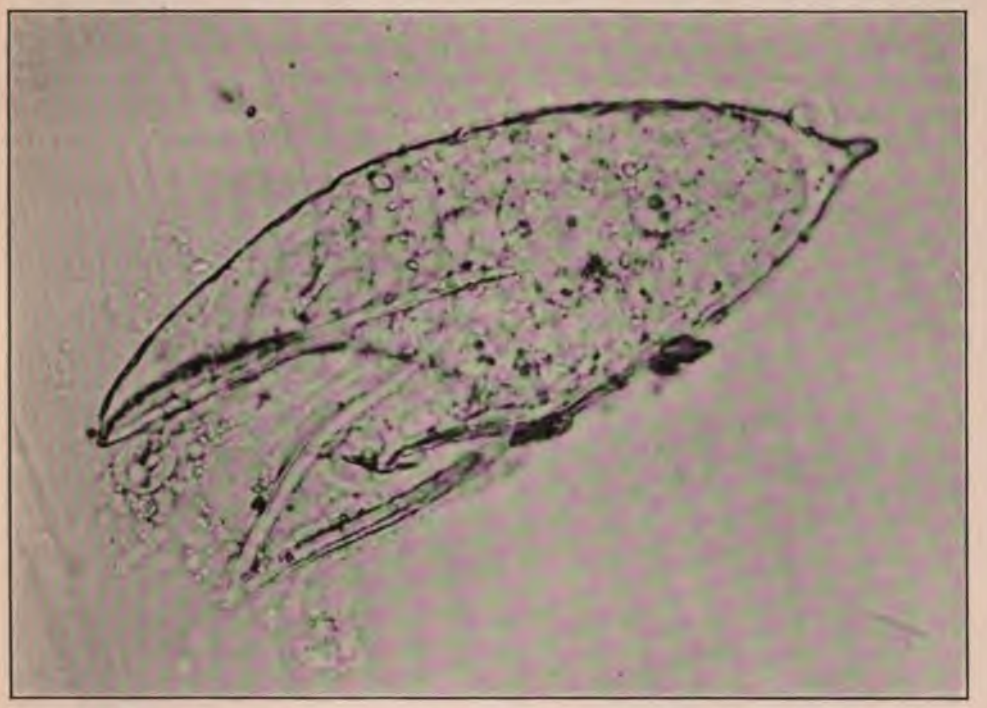


FIG. 132.—SHELL OF THE OVUM AFTER MIGRATION OF THE EMBRYO OF DISTOMA HEMATOBIA. Magnified 500 diameters. (Dr. Pool's case.)

Often calculi are formed, and thus the individual is exposed to any of the destructive lesions of the kidney due to obstruction and infection—i. e., hydronephrosis, pyonephrosis, etc.

The Blood.—A moderate leucocytosis is usually present. An increased proportion of eosinophiles is commonly observed. In fifty cases studied by

[1] O'Neil, *Boston Medical and Surgical Journal*, October 27, 1904.

Douglas and Hardy, the eosinophilia amounted on the average to 16.48 per cent. The large polynuclear cells are reduced in number.

Symptoms and Diagnosis.—Without going into all of the symptoms in detail, it may be said that the most constant symptom of the disease is hematuria, and that the diagnosis depends upon finding the ova in the urine or in the feces.

In the early stages no other symptoms are necessarily present. Later, inflammation of the bladder, vesical or renal calculi, occur. The prostate and seminal vesicles may be invaded with abscess formation. There may be symptoms of proctitis with bloody stools. Profound anemia and exhaustion, sepsis, or some fatal kidney complication may end life.

I append the history of one of the very few cases found in New York, through the kindness of Dr. E. H. Pool, who has also permitted me to use the microphotographs of the urinary sediment here reproduced.

A Case of Bilharzia Hematobia.—The patient was a young man, twenty years of age, an Algerian by birth, a sailor by occupation. When he was eight years of age he went to Ismailia on the Suez Canal, Egypt, and remained there for five years. During that time he went in swimming almost daily, both in the

Fig. 133.—Embryo of Distoma Hematobia after Migration from the Shell. Magnified 500 diameters. (Dr. Pool's case.)

Suez itself and in the neighboring streams and ponds. The next five years h been spent on a Greek ship in the Mediterranean. He had left this vessel two ye ago at Marseilles, and there he contracted gonorrhea four days after intercour He had had with that attack very little pain and frequency of micturition, but h had a characteristic discharge which disappeared at the end of fifteen days un

urethral injections. A fortnight later he went back to Algiers, where it was intensely hot, and shortly after reaching the country, as he supposed on account of the intense heat, he noticed that all of his urine was diffusely red. He remained in Algiers for three or four months and the condition persisted. He had no other symptoms and was able to go about his regular occupations. As soon as he left the country the diffusely bloody urine changed to the characteristic hematuria of the disease—viz.: after he had passed a normal amount of fairly normal-looking amber-colored urine and when the bladder was apparently empty, with an involuntary spasm there was a discharge of a drachm or two of a thin bloody fluid. This condition had persisted up to the present time intermittently. The man spent nine months in Cuba, and for the last six months had been in the United States. At the present time he also complained of indefinite pain in the loins and of a feeling of weakness which prevented him from doing any earnest work.

The physical examination showed a well-nourished young man. Examination of heart, lungs, abdomen, rectum, etc., was negative.

The following was the report of the examination of urine:

April 8, 1903. Volume voided in twenty-four hours, 1,950 c.c. Reaction, acid. Color, amber. Sediment, moderate in amount; reddish white. Specific gravity, 1.019. Albumin, trace. Sugar, negative. Urea, 41,301 grams in twenty-four hours. Indican, no excess. Acetone, negative. Chlorid, 13.6 grams in twenty-four hours. Phosphates, no excess. Examination of sediment obtained by centrifuge showed: Blood, very small amount; pus, small amount; mucus, small amount; extremely few hyaline casts; numerous squamous epithelial cells; many ova of the Bilharzia, and numerous structureless threads.

Examination of blood: Red cells, 3,340,000. Hemoglobin, 86 per cent. Leucocytes, 6,600. Differential count: Small lymphocytes, 31.5 per cent. Large lymphocytes, 6.5 per cent. Polymorphonuclear neutrophiles, 52.5 per cent. Eosinophiles, 9.5 per cent.

Several other animal parasites may cause hematuria, among them Strongylus gigas and Nephrophages sanguinarius. They are, I believe, unknown in America. The latter occurs in Japan.

CHAPTER XXIII

THE URINARY BLADDER, ANATOMY, METHODS OF EXAMINATION, AND CONGENITAL DEFECTS

TOPOGRAPHICAL ANATOMY OF THE BLADDER

(*Partly Adapted from Merkel*)

THE anterior half of the pelvic cavity is occupied by parts of the genito-urinary apparatus. The largest part of the space is filled by the urinary bladder. The other structures—i. e., ureters, vasa deferentia, seminal vesicles, and prostate—are in apposition to it. The bladder is ordinarily described as possessing an apex or vertex, a *base* or *fundus* and a *body*, or the main portion of the bladder. Into the base of the bladder empty the ureters, and from it emerges the urethra, the internal urinary meatus being situated at the anterior limit of the bladder floor. From the anterior wall, at the apex of the bladder, the median umbilical ligament extends upward to the umbilicus, the remains of the urachus.

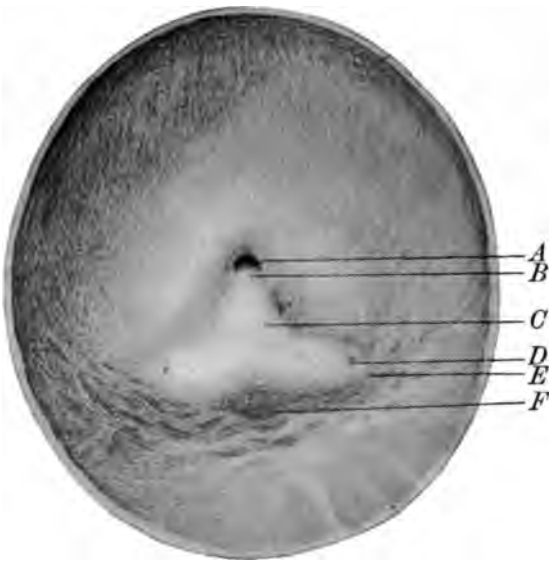


FIG. 134.—THE URINARY BLADDER; THE UPPER PORTION OF THE BLADDER HAS BEEN CUT AWAY; THE OBSERVER IS LOOKING FROM ABOVE UPON THE FLOOR OF THE BLADDER. Drawing made from the bladder *in situ*. Natural size. *A*. Urethra. *B*. Uvula vesicæ. *C*. Trigonum. *D*. Ureter. *E*. Plica ureterica. *F*. Fovea retroureterica. (After Merkel.)

The lateral umbilical ligaments are the obliterated umbilical arteries. They come into contact with the bladder only when it is much distended.

The *external surface* of the bladder is smooth under all conditions, whether full or empty.

The *muscular wall* of the bladder is surrounded by a loosely meshed layer of connective tissue. Through this layer the upper part of the bladder can be readily stripped from surrounding structures by blunt dissection with the fingers or a sponge holder; advantage of this fact is taken in many intrapelvic operations.

The *lining mucous membrane* of the interior of the bladder is, when empty, thrown into deep folds; as the bladder distends, these folds are gradually obliterated. The innermost layer of muscular bundles then becomes visible, arranged in a network, the muscular ridges projecting slightly, with slight hollows between them. In the *hypertrophied* bladder these ridges and furrows become more marked, so that the bladder is said to be *trabeculated.* The interspaces may even become so deep as to harbor a stone or form a deep pocket or *diverticulum.*

When the normal bladder is distended beyond a medium grade, the ridges and furrows disappear and the surface becomes quite smooth.

The floor of the bladder, or *fundus,* is unlike the remainder of the organ; here no muscular folds or bundles are to be seen; instead, one finds a flat surface—the *trigonum vesicæ.* Throughout this entire area the mucosa is firmly adherent to the underlying muscular layer. The trigonum is abundantly supplied with nerves, and is much the most sensitive portion of the bladder, the remainder being relatively insensitive to touch, but highly sensitive to distention, as everyone knows from experience. Two slight folds of mucous membrane can be noted converging toward the ureteric orifices. The *trigonum* is the triangular surface between the ureteric orifices and the internal urinary meatus, or urethral orifice. As the ureters pass obliquely through the bladder wall they create two slight ridges, passing to the ureteric orifices, the *plica ureterica.* Between the orifices these ridges are prolonged toward the median line, where they unite. This ridge is more or less marked in different bladders; its center may be interrupted, forming a slight central depression. From the center another slight ridge extends forward to the urethral orifice; its anterior extremity enters the urethral orifice, and here forms a slight elevation, known as the uvula. In old age, hypertrophic enlargement may occur at this point, causing obstruction. (See Prostate.) These several ridges are only seen when the bladder is empty and contracted; when distended, the surface of the trigone is quite flat.

The *ureteric orifices* are about 25 mm. apart, and are distant from the urethral orifice 20 to 25 mm. They are oval slits, 4 to 5 mm. in length, and have been likened in shape to the mouth orifice of a flute. The orifices are created at the expense of the anterior wall of the canal. In passing the ureteral catheter, it is important to remember this mechanical detail. The oblique perforation of the bladder wall by the ureters explains the valvular action here exhibited. Increased intravesical pressure compresses the ureters so that regurgitation from the bladder does not take place. This is shown even in the dead bladder; air injected into the bladder through the urethra does not escape through the ureters.

The *urethral orifice* is round, or of half-moon shape. It is not usually depressed or funnel-shaped, but is simply an orifice in the level bladder floor. In the normal bladder, as the individual stands erect, the urethral orifice is usually at the lowest point of the bladder, though sometimes a slight depres-

sion exists in front of it before the bladder wall rises behind the symphysis. Thus, small stones coming down from the kidney are often readily evacuated during urination, while larger ones may occlude the orifice. In an anatomical sense the bladder possesses no neck. The so-called *collum vesicæ* does not exist, though the term is still occasionally used to indicate either the prostatic urethra or the trigonum.

Ultzmann considered that, physiologically, the prostatic urethra was a part of the bladder. From a practical point of view his ideas upon this subject were important. I therefore insert a quotation embodying his ideas upon this point:

When urgency is caused by considerable distention of the bladder the weak sphincter internus, consisting of organic muscular fibers, is overcome by the detrusors of the bladder and the urine forces its way into the pars prostatica. At that moment the pars prostatica and the bladder form one common cavity and the existence of a neck of the bladder is distinctly shown. At the moment of greatest urgency it is only the sphincter externus, consisting of transversely striped muscular fibers and under control of the will, that resists the outward course of the urine. On voluntary relaxation of these muscles the urine immediately rushes forth in a powerful stream. But the intimate connection between the prostatic part of the urethra and the bladder is still more strongly attested by the pathological conditions of the prostate. In nearly all diseases of the latter, vesical symptoms with urgency are present and in a large number of diseases of the bladder the etiological factor may be traced to a simultaneous affection of the prostate, so that in many cases a successful local treatment of the disease of the bladder can be carried out only by subjecting the pars prostatica to a simultaneous energetic local treatment. The weak sphincter internus offers but slight resistance and loses its power at the least affection of the prostate. These facts alone indicate sufficiently that the term "neck of the bladder," even if not strictly in accordance with anatomical facts, is for the physician and surgeon an eminently practical appellation.

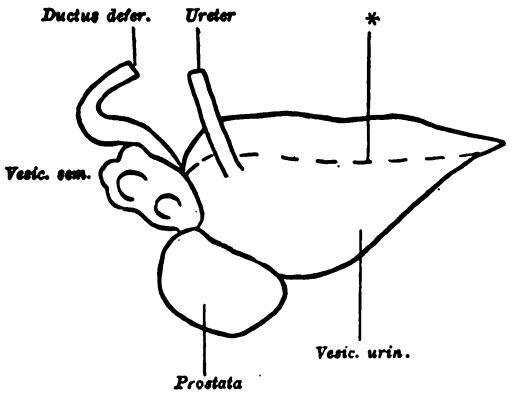


FIG. 135.—EMPTY BLADDER IN PROFILE. (After Dixon.) * Line of reflection of the peritoneum.

The so-called *Fovea retroureterica, Fovea retrotrigonalis, Bas fond* of the bladder—i. e., a depression of the bladder behind the interureteric line—is always a pathological development. (See Retroprostatic Pouch, under Vesical Calculus and Prostatic Hypertrophy.)

Shape and Position of the Bladder.—The shape and also the position of the bladder change according to the quantity of fluid it contains. An empty and contracted bladder has a sagittal and transverse diameter of 5 to 6 cm.; a vertical diameter of 3 cm. On median section the shape of the empty bladder is triangular; both the outer wall and the cavity of the organ conform to this

shape. The form of the bladder, viewed as a whole, is a tetrahedron. At the four angles are placed, above and in front, the median umbilical ligament, urachus; on either side, the ureters; below and in front, the urethral orifice.

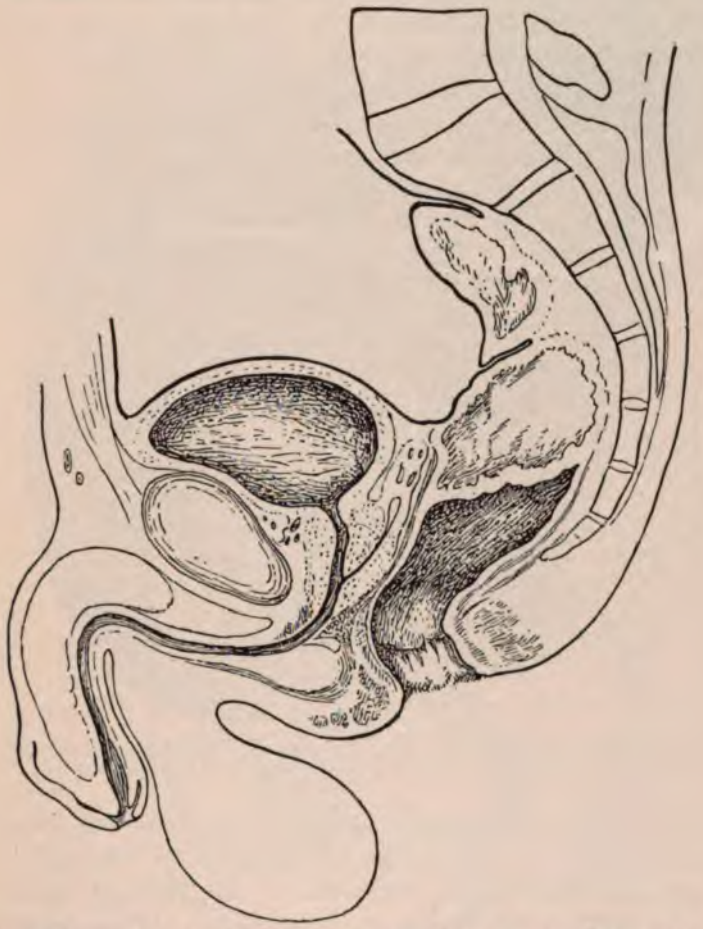


FIG. 136.—MEDIAN SECTION OF THE BODY, SHOWING THE SHAPE OF THE BLADDER DURING SLIGHT DISTENTION. (After Merkel.)

The borders of the tetrahedron are rounded, and, viewed from the side, the bladder is somewhat pear-shaped (see Fig. 135). At any rate, the bladder cannot be described as globular when empty; on the contrary, it is flattened, and has a superior surface, from the anterior border of which the obliterated urachus ascends. The interior of the bladder has a similar shape to the exterior—i. e., it possesses angles. The two lateral angles on either side of the ureteric orifices (Recessus laterales, Luschka), are especially pronounced. They also explain why it is that in the empty bladder an instrument may be moved laterally with some freedom (Delbet-Guyon).

When bladder and rectum are both empty, the former lies at the bottom

of the pelvis. When the rectum is distended the bladder is raised, so that its vertex reaches to, or nearly to, the upper border of the symphysis. When the bladder begins to distend, the rectum being empty, the distention begins in the posterior part of the bladder; the anterior wall remains practically

FIG. 137.—MEDIAN SECTION THROUGH THE MALE PELVIS. The bladder distended, the rectum empty. *A*. Prevesical space (space of Retzius). (After Merkel.)

quiescent; the lateral recesses also distend, and the transverse diameter reaches its maximum during the process first, normally 12 cm. ($4\frac{3}{4}$ in.).

The organ, during moderate distention, is still flattened on its upper surface, and is, on median section, almost wedge-shaped. When further distended, the anterior wall begins to stretch. The entire bladder rounds itself more and more; the vertex rises above the symphysis. The greatest distention, however, continues to occur in the posterior part; the anterior wall remains shorter, so that the median ligament (urachus) does not pass from the summit of the distended bladder, but from a point on its anterior surface. The trigonum takes but little part in the distention unless it be extreme, when its transverse diameter is increased. The lateral distention is limited by the bony and muscular walls of the pelvis, and in extreme distention the bladder must increase in size chiefly in an upward direction. The shape of the greatly distended bladder is also considerably modified by the rectum, and its degree of distention, as well as by the pressure of the overlying intestines. When the rectum is empty, the floor of the bladder descends somewhat, and both anterior and

posterior portions may expand considerably in an anterior and posterior direction, as well as laterally, so that the bladder may rise only moderately, and still retain a flattened though somewhat globular shape. If, however, the rectum is distended, the pelvic space is limited, and the bladder must rise into the abdominal cavity. The form of the bladder changes from an ovoid with its long axis horizontal into a similar figure with its long axis more or less vertical.

The greatly distended bladder does not exactly conform to the shape it would have were it permitted to expand freely in all directions, its shape being determined to a great extent by the resistance, or want of resistance, of surrounding structures, and especially by the weight of the intestines, which tend to crowd it downward, so that it is molded, so to speak, into the shape of the pelvic cavity, its vertex being flattened by the same force. When the

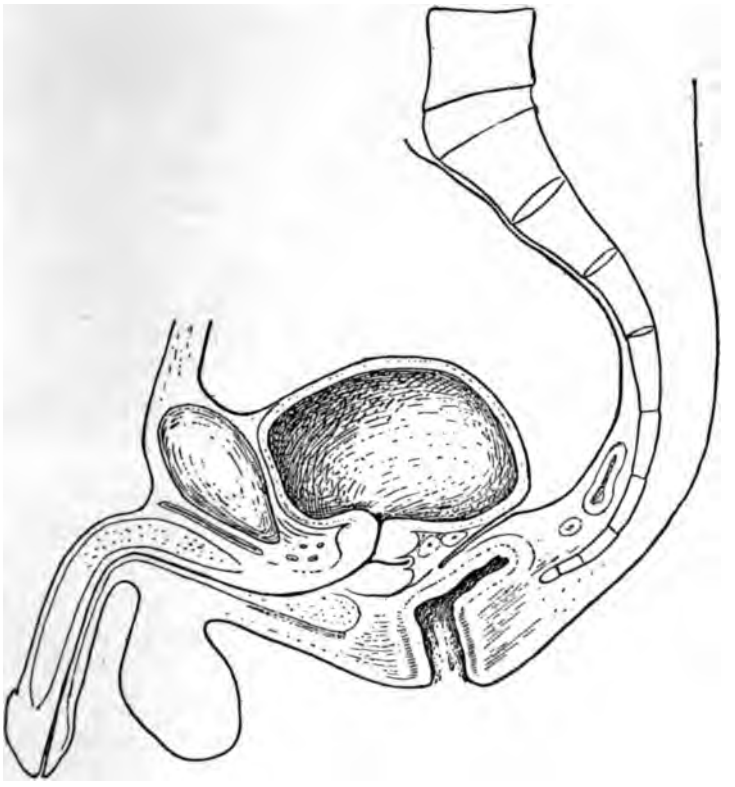


FIG. 138.—MEDIAN SECTION OF THE PELVIS. The rectum is empty. The bladder is partly filled and appears flattened on account of the weight of the intestines. (Merkel, after Symington.)

bladder is removed from the body, or even when the abdomen is opened, the pressure being relieved, the flattened appearance seen in frozen sections disappears, and the vertex becomes rounded. The position of the bladder is, as stated, greatly modified by the condition of the rectum. When the rectum is empty, very considerable distention of the bladder is necessary before it

appears above the pubes. When the rectum is distended, on the other hand, the bladder and the anterior peritoneal fold rise above the pubes, so that the bladder is readily accessible without encountering peritoneum.

Peterson's bag, or colpeurynter, was formerly much used in the operation of suprapubic cystotomy, and depended upon these facts for its efficacy. It is, I believe, scarcely used at present. A moderate distention of the bladder with water, and a little care, render it quite easy to expose the bladder above the pubes without wounding the peritoneum. When the space of Retzius is opened, the fat and the peritoneal fold are easily pushed upward with the finger and held out of the way with a blunt retractor, if necessary, while the operation is conducted upon the bladder.

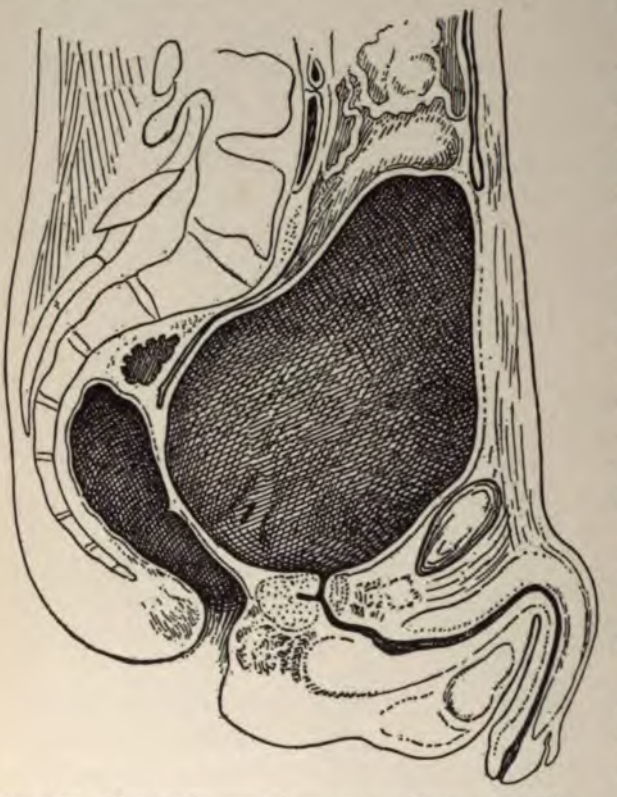


FIG. 139.—MEDIAN SECTION THROUGH THE PELVIS. Bladder greatly distended showing the high point to which the peritoneal reflection is raised. (Merkel, after Rüdinger.)

The bladder may be freed from peritoneum in this way, 6 cm. in an antero-posterior direction.

In some cases the peritoneal fold is adherent to the symphysis, but the attachment is not firm, and is easily separated.

The approach to the bladder by the suprapubic route is, for obvious reasons, rendered easier by placing the patient in the Trendelenburg posture.

Fehleisen found the following relations between the peritoneal fold and the symphysis, under different conditions of distention of the bladder and rectum.[1]

Bladder.	Rectum.	Peritoneal fold above symphysis.
300 c.c.	Empty.	0.5 cm.
200 c.c.	480 c.c.	4.0 cm.
630 c.c.	Empty.	2.0 cm.
420 c.c.	500 c.c.	8.5 cm.

[1] Fehleisen, *Archiv für klin. Chirurgie*, vol. xxxii, S. 563, 1885.

Capacity of the Bladder.—It is hard to fix any definite limit on the capacity of the normal bladder; it varies widely among different individuals, and in the same individual at different times.

Habit and environment exercise an important influence. An individual who lives so that he may empty his bladder at any moment will naturally do so at the first inclination. Another, living under other conditions, where he must often postpone the act in spite of desire, will acquire a more capacious bladder. Nervous influences have also an important bearing; every one knows that at certain times he must urinate frequently, while at others his bladder bears a much greater distention without discomfort. The degree of distention causing desire to urinate varies, according to Duchastelet, between 125 and 250 c.c. Testut considers the maximum physiological distention 300 to 500 c.c. Delbet considers 350 c.c. the normal limit. G. S. Huntington informs me that the normal limit of distention is about 350 c.c.; extreme normal distention might reach 500 c.c.

Such a bladder measures 14 cm. vertically, or through its long axis, 12 cm. horizontally from side to side, and 10 cm. antero-posteriorly. In cases of retention of urine, the bladder may become enormously distended, so that it reaches to the umbilicus or above, or may even fill the greater part of the abdomen and cause dyspnea, even edema of the legs from pressure on the veins. One hundred ounces or more may be withdrawn through a catheter under such circumstances.

For surgical purposes, cystoscopy or cystotomy, 100 to 125 c.c. is an abundant quantity to introduce into the bladder. In cases of chronic interstitial cystitis (atrophied bladder) the capacity of the bladder may be reduced to a few drachms.

Relations of the Bladder.—*Relations with the Peritoneum.*—We have already spoken of the changes in the relations between the bladder, peritoneum, and abdominal wall, when the bladder and rectum are empty or distended, respectively. The peritoneum covers the entire superior surface, and the lateral surfaces, down to the line of the obliterated hypogastric artery, or a line extending from the urachus to a point somewhat below the summit of the seminal vesicles; and the upper part of the *posterior surface* to the bottom of the *rectovesical pouch*. This pouch is usually filled with coils of small intestine separating the bladder and rectum. Here peritoneum reaches to a point just below the upper ends of the seminal vesicles and about an inch above the prostate—i. e., three inches from the anus. It forms the upper limit of the triangular area over which the rectum and bladder are closely adherent (Woolsey).

Certain differences exist according to *age* and *sex*. In *children* the bladder is situated at a higher level, on account of the narrow pelvis; nor is the fundus fully developed. For this reason the peritoneum reaches much lower on the posterior vesical wall than in adults, and is therefore much more easily wounded in operations upon the perineum and rectum. On the other hand,

the anterior bladder wall of children is relatively more accessible than in adults. The peritoneal fold arises above the pubes from slighter degrees of distention. In the *female* the superior portion of the body of the bladder is free

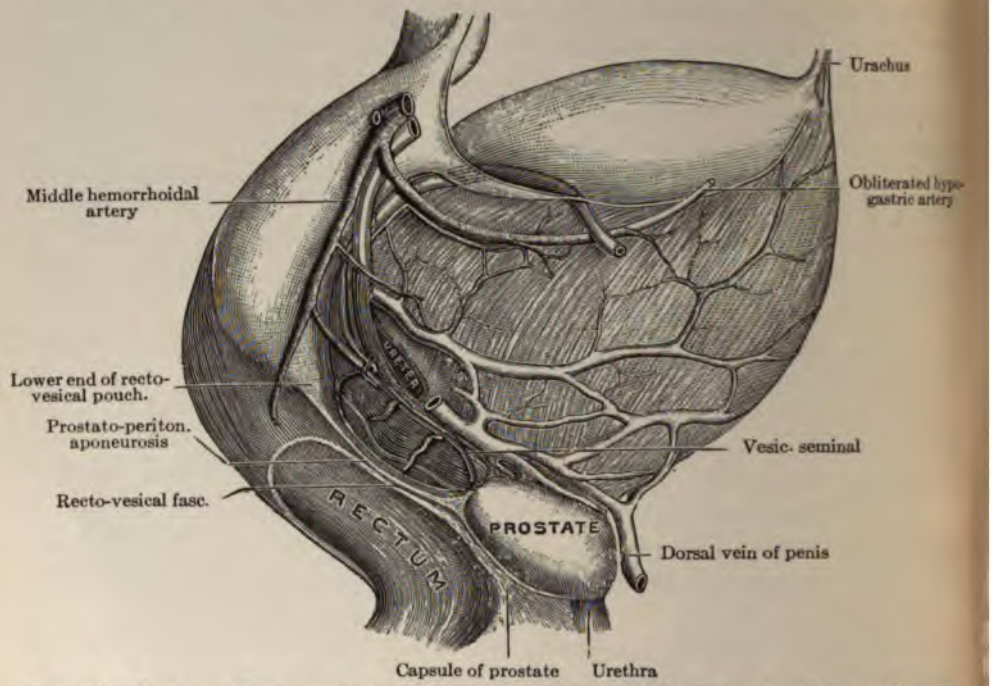


FIG. 140.—RELATIVE POSITION OF THE BLADDER, URETER, RECTUM, PROSTATE, SEMINAL VESICLES, VAS DEFERENS AND THEIR VESSELS, VIEWED FROM THE RIGHT SIDE. (Woolsey, after Joessel.)

from peritoneum for a greater distance than in the male. The posterior wall lies close to the uterus, and the peritoneal fold does not reach so low as in men.

The Bladder Wall.—When the bladder is greatly distended the thickness of its wall may be reduced to a minute fraction of an inch; even the mucous membrane is drawn out so that but a single layer of flattened epithelial cells can be demonstrated. When moderately distended, the wall is about an eighth of an inch thick; when empty, the wall of the bladder may be half an inch thick, or more.

The muscular coat of the bladder consists of smooth muscular fibers arranged in two layers, an external layer of vertical muscular bundles; these are most abundant on the anterior and posterior walls of the bladder; and an internal layer of circular and oblique bundles. The internal layer projects slightly upon the interior surface of the bladder, forming an irregularly rhombic pattern. Around the internal urethral orifice the circular bundles constitute the *internal sphincter of the bladder.* The entire muscular coat of the bladder forms the *detrusor vesicæ.* The *epithelium* of the bladder consists of several layers. The innermost cells are somewhat flattened, the middle cells are polygonal, the outer cells cuboidal or nearly cylindrical.

METHODS OF EXAMINING THE BLADDER

We may examine the bladder from without by the ordinary methods of inspection, palpation, percussion, and auscultation. The interior of the bladder may be examined by the introduction of sounds and catheters through the urethra. We may expose the interior of the bladder for inspection and palpation by a suprapubic incision through its wall. In women we may palpate the interior of the bladder with one finger introduced through the dilated urethra, the other hand being placed upon the abdominal wall; though this method is now rarely necessary, and is seldom practiced. The *male* bladder may be palpated through a perineal incision in the floor of the membranous urethra, one finger being introduced through the dilated pars prostatica into the bladder. This method may be aided by a suprapubic incision into the space of Retzius. When the prostate is greatly enlarged this method may be difficult or impracticable. The interior of the bladder may further be inspected through an optical apparatus introduced through the urethra—the electric cystoscope. In the *female* the bladder is open to direct inspection through a straight metal tube introduced through the urethra (Kelly's tubes).

Each of the methods is useful, though usually in the diagnosis of bladder disease it is necessary to use several methods of examination, and to combine them with a chemical and microscopical examination of the urine.

Inspection.—For ordinary purposes of examination the patient must lie flat on his back, the body uncovered from the navel to the knees. If the patient is thin and has retention of urine, the bladder may form a plainly visible rounded tumor in the hypogastrium, nearly central, or a little more prominent to the right. In women who come complaining of bladder symptoms, we may see at once a prominent tumor, either uterine or ovarian, sometimes inflammatory, which may by pressure be causing frequent or painful urination, or both.

Percussion.—If the distended bladder lies in contact with the abdominal wall over a considerable area, it will give *flatness on percussion*; and pressure over the tumor will, unless the patient has anesthesia of the vesical neck, cause a desire to urinate. The fact that tympanitic resonance exists above the pubes does not necessarily indicate that the bladder is empty, nor even that it is not distended. A bladder previously greatly distended may have quite lost its muscular tone. Such a bladder will enlarge laterally without rising much out of the pelvis. In some cases the peritoneal fold will rise but little above the pubes, even though the bladder is distended, and the space between the bladder and the abdominal wall may be occupied by intestine. In women who have pelvic peritonitis the intestine may be adherent to the abdominal wall as far down as the pubes.

Palpation.—If the bladder is distended, palpation may give a sense of elastic tension—i. e., fluctuation; and, as stated, the pressure will cause the patient to desire to urinate. In thin persons and those with flabby bellies this

sign of a distended bladder will be distinct. In the muscular and stout it will be obscure or absent. A combined rectal or vaginal examination, as the case may be, will sometimes aid in detecting this sign; and of course may reveal many other important conditions. In men with greatly enlarged prostates we may be unable to detect fluctuation in this way, since the hard prostate intervenes and obscures it. We may fail to detect fluctuation in habitually dilated bladders, the resistance of the bladder wall being insufficient to give the feeling of elastic tension. In cases of acute retention, however, the bladder may feel as hard as a solid growth. The distended bladder has been incised and even extirpated by surgeons in the belief that they had to do with a cystic tumor.

Rectal and abdominal palpation under general anesthesia, the sphincter ani having been dilated, permits a thorough examination of the bladder; and if, in addition, the index finger of the left hand be introduced through a small incision above the pubes into the space of Retzius, the examination of the bladder wall, the prostate, the seminal vesicles, and the lower portion of the ureters may be very complete indeed. The bladder should be empty.

Auscultation of the Bladder.—This method is only practiced during the operation of litholapaxy. When extracting the fragments through the evacuator tube, the ear or a stethoscope may be applied to the abdominal wall over the bladder. As long as fragments still remain, they may be heard striking the edge of the eye of the tube when the pump is in operation.

Examination of Interior of the Bladder by Introduction through the Urethra of Sounds, Catheters, and Searchers.—Much information may be gained by the introduction of instruments through the urethra into the bladder. Before describing the technic of the various methods in use, and the knowledge to be gained therefrom, a few words of caution may not be amiss. In disease of the lower genito-urinary tract the urethra and bladder are commonly inhabited by a variety of pathogenic germs. Among normal individuals, pathogenic bacteria are often found upon the external genitals and in the urethræ of both sexes. The mucous membranes of the urethra and bladder are delicate and readily wounded; and when wounded are peculiarly susceptible to septic infection, even in health. This is notably true of the deeper portions of the male urethra. When *uninjured* and *healthy* the bladder shows an extraordinary degree of immunity to bacterial invasion; when *wounded* this is lost. When already diseased, and more especially in the presence of *obstructive lesions*, enlarged prostate, stricture of the urethra, paralysis of the detrusor of the bladder, etc., this susceptibility, on account of imperfect drainage, is notably increased. Therefore *catheterism* should be regarded as a serious surgical procedure, *a fortiori* when practiced upon an individual for the first time. All instruments and solutions should be sterile. Metal instruments should be boiled for ten minutes in a two-per-cent solution of sodium carbonate and rinsed in sterile water, or sterilized in the flame of an alcohol lamp or Bunsen burner. Some silk instruments, and all soft-rubber instruments, may be boiled

in plain water. They will not stand boiling soda. Silk and rubber instruments and cystoscopes may be disinfected in formaldehyd vapor, though the method is troublesome. All instruments should be mechanically cleansed with soap and water after use; and those which permit it, boiled again at once. A soluble sterile lubricant should be used; probably one of the sterile preparations of Iceland moss, now everywhere obtainable—the so-called K-Y, for example. In default of these, glycerin or boroglycerid. Vaselin is not a good lubricant for urethral instruments. It is insoluble in water, and coats the mucous membrane with a layer impervious to antiseptic solutions.

The external genitals should be cleansed, and if anterior urethritis is present, the anterior urethra should be washed with salt solution or boric-acid solution. In the presence of acute gonorrheal urethritis in the male, *no instrument* should be introduced into the bladder, if this can be avoided. Catheterism should be followed by cleansing of the bladder and urethra with some non-irritating solution. My own preference is as follows: Eight or ten ounces of a solution of potassium permanganate, of a strength of 1 to 2,000 of water, is introduced into the bladder by means of an Ultzmann's hand syringe and a silk catheter coudé, or the Ultzmann silver irrigating catheter. The patient then rises and empties his bladder. If the bladder is insufficient, he empties his bladder as far as he is able, a soft catheter is then introduced while the patient stands erect, and the remaining fluid removed, lest the bladder be irritated by the solution. If salt or boric acid be used, the residue may be disregarded; but see Retention of Urine.

After catheterism Keyes and others prefer an instillation of nitrate of silver, 1 to 1,500, distributed along the whole course of the urethra, introduced through the Ultzmann drop syringe or Keyes syringe (see Fig. 141).

Fig. 141.—Keyes Syringe for Instillation in the Deep Urethra.

Others prefer a ten- or twenty-per-cent solution of argyrol. The surgeon's hands should be clean. This end is accomplished best by the use of rubber gloves or of chlorid of lime and sodium carbonate.

Last, but not least, the instrumentation should be conducted with extreme gentleness, and the trauma reduced to a minimum.

In examining the bladder metal instruments give more information than others. Such instruments are known as *searchers*; they may be of solid metal, or hollow like a catheter. The former are heavier, and have the advantage that they transmit sensations to the hand holding them more accurately, and

make a louder sound when they strike a stone. If made in the form of a catheter, they should be heavy and of simple construction. The advantage of the catheter form of searcher is that with it the bladder may be examined under various degrees of distention, its capacity measured, and its sufficiency tested—i. e., whether or not it is capable of emptying itself. Whether a solid

FIG. 142.—THOMPSON'S SEARCHER.

sound or catheter be used, the instrument should have the short vesical curve, "the short Mercier curve." A long curve limits the free movement of the beak of the instrument within the bladder. A short curve is especially important when searching for stone; since, if a pocket exists behind the prostate in which a small stone rests, an instrument with a long curve, the beak of which

FIG. 143.—GUYON'S SEARCHER.

cannot be rotated backward, may fail to touch it. The size of the shaft of the instrument should be from No. 18 to 20 of the French scale. The beak may be cylindrical or slightly bulbous at the tip, or flattened laterally, *never* conical. This last form is much more likely to wound the bladder, and to catch in the ridges of an hypertrophied or trabeculated bladder.

Several forms of searchers in common use are figured in the text—Thompson's, Guyon's, and William K. Otis's modification of Thompson's later model. Thompson's catheter searcher has a small metal plug in the handle to close the catheter. Both the Thompson and the Guyon searchers have a cylindrical handle. The modification of Otis has the beak flattened laterally, according

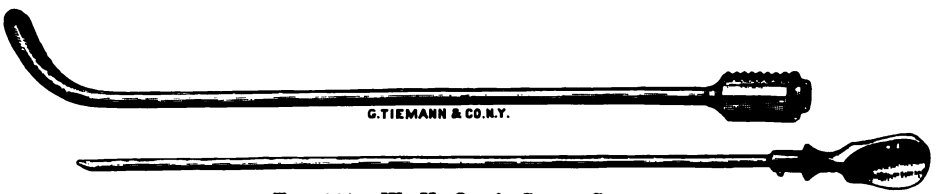


FIG. 144.—W. K. OTIS'S STONE SEARCHER.

to Thompson's later model, and solid. The handle is flat and heavy, and is continued through the shaft of the instrument as a solid, straight obturator to the junction of the beak with the shaft. Upon withdrawing the handle and obturator the instrument becomes a catheter. It thus combines the advantages of weight and rigidity with those of a catheter (see Fig. 144).

Before introducing a rigid instrument into the bladder we should always palpate the prostate. If this be notably enlarged it may be impossible to enter the bladder with a short-curved instrument. A dilated prostatic urethra may permit some lateral mobility of the beak of the searcher, and we may thus think the instrument is in the bladder, and the presence of a stone may remain unsuspected. Rectal palpation will permit us to foresee the probable difficulties, and we shall thus be better able to select an instrument with a proper curve, and to know how deeply it must be depressed and how far inserted in order to enter the bladder.

If the prostate is normal its upper border is readily reached by the forefinger in the rectum, and the less resistant bladder is felt above it. When the prostate is much enlarged the bladder is lifted to a higher level, and the prostatic urethra is lengthened. In some cases we cannot reach the upper limit of the prostate with the finger, nor even near it. In these catheterization may be difficult, and with an instrument of short curve impossible.

With a normal prostate, after the beak of the instrument has entered the membranous urethra, depression of the shaft between the patient's thighs to the horizontal will suffice to enable us to slide the instrument into the bladder. If the prostate be greatly enlarged, the handle of the instrument must be sunk deeply between the patient's thighs, below the horizontal, in order to enter the bladder. In such cases it is necessary to elevate the pelvis on a firm cushion, or to use an especially constructed table. Such a table may have a step in it, six inches high, the buttocks resting on a higher level, or the table may be made with a suitable hole in it, which will permit the instrument to be depressed below the level upon which the patient lies.

Technic of Catheterization.—A description of the technic of catheterization is here given; though it must be said that the proper introduction of a rigid instrument into the bladder can only be learned by practice, first upon the cadaver, later upon the living subject. The keynote of the manipulation should be from start to finish extreme gentleness.

The surgeon may use either hand for holding the sound or catheter. If he uses his right hand, it is well to stand upon the left side of the patient, though every surgeon usually acquires a habit of his own in passing sounds, irrespective of rules. Personally, I usually stand on the right of the patient and hold the instrument in the right hand. Dr. Gouley, who handled urethral instruments with great skill, did not touch the penis, but simply hooked the beak of the instrument into the meatus, and insinuated it gently onward. For the beginner the following is the safest procedure. It was practiced by Prof. Robert Ultzmann, of Vienna, a master in the manipulation of urethral and bladder instruments. Cleanliness and the antiseptic precautions elsewhere described having been fulfilled, the patient is placed on his back, made comfortable, and his fears quieted. His body is uncovered from above the navel to the knees.

One may, or may not, introduce 20 to 30 minims of a 4-per-cent cocain solution into the anterior urethra, and leave it for five minutes, milking the urethra backward for a moment, while the meatus is compressed laterally. In nervous patients and those who are very sensitive, the measure is useful and de-

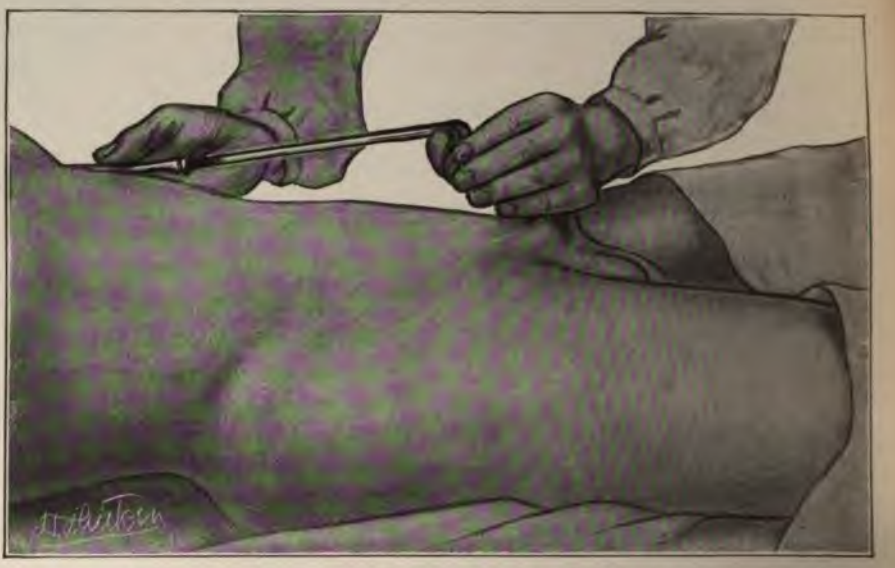


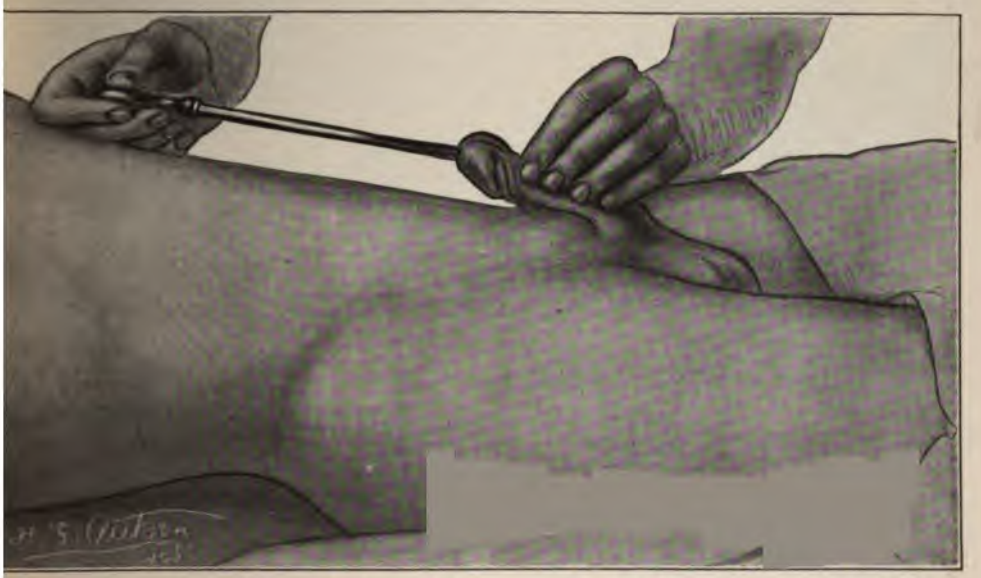
FIG. 145.—FIRST STAGE IN THE PASSAGE OF A SOUND. The handle of the instrument is held in or near the middle line of the body and low down parallel with the abdominal wall, or nearly so. The point having been inserted into the meatus the penis is drawn over the shaft of the instrument, much as one would thread an angleworm upon a fish hook. (After Watson and Cunningham.)

sirable. It spares the patient a good deal of discomfort and does much to give him confidence in the surgeon's skill; notably, if he has been sounded by others without it. There are two conditions when it is well to omit it: (1) In examining for stricture. (See Diagnosis for Stricture of the Urethra.) (2) When the instrumentation is to be followed by an irrigation or an instillation of nitrate-of-silver solution. In this case it is omitted for chemical reasons, since silver chlorid is at once precipitated by hydrochlorate of cocain.

A small quantity of sterile Iceland moss jelly is squeezed out of its containing tube on to the glans penis over the meatus.

The surgeon stands on the left side of the patient, holding the instrument in his right hand like a penholder, with the convexity of its curve upward. The beak of the instrument is placed just over the symphysis pubis. The shaft is held close to, and parallel with, the abdominal wall, and exactly in the median line of the body. The penis is raised with the left hand and the meatus is caused to gape with the forefinger and thumb. The tip of the instrument is then permitted to sink into the meatus. The penis is then drawn up on the instrument, as Ultzmann used to say, "as one would thread an angleworm on a hook," until resistance is encountered. The shaft of the sound is then

slowly rotated to the vertical, but without any effort to push it onward. The tip of the instrument is now in the bulbous portion of the urethra. The position of the sound is readily determined by the tip of the little finger of the left hand placed on the perineum. The rotation of the sound and of the penis is continued, and the shaft of the instrument is slowly sunk between the patient's thighs until it reaches a horizontal position. The beak is now in the bladder. After the shaft has reached the vertical, one should be careful to observe from the position of the flat handle, and from the general direction of the shaft, that the entire instrument is exactly in the median line. No force is permissible at any time. The instrument under normal conditions should glide merely by its own weight into the bladder. While the whole performance is exceedingly simple and easy in the average case if these rules are carefully followed, yet under certain conditions, even in the absence of stricture, difficulties may occur. In fat people it is not possible to hold the sound horizontal and parallel with the abdominal wall. The sound being introduced will impinge upon the symphysis. In these cases it is best to begin the introduction with the sound parallel to Poupart's ligament; indeed, many surgeons prefer this position in



IG. 146.—SECOND STAGE IN THE PASSAGE OF A SOUND. The penis is drawn up upon the shaft of the instrument until a distinct sense of resistance is felt. The handle of the sound is then gradually elevated and is meanwhile kept precisely in the median line. When the sound has reached an angle approaching thirty degrees with the vertical its point will be entering the bulbous portion of the urethra. (After Watson and Cunningham.)

ll cases. As the sound sinks below the peno-scrotal angle, it is gradually brought toward the median line. In elderly men, and even in young men, if heir muscles are flabby, another hindrance of a much more important character may be found here. When the bulbous portion of the urethra is dilated, s the sound is rotated to the vertical, the beak may sink below the level of

the orifice in the deep perineal fascia, through which the urethra passes. When the shaft is rotated beyond the vertical, its tip catches against this fascia, and its further progress is stopped. If the rotation is continued the convex portion of the sound becomes more prominent in the perineum. Slight rotary movements of the shaft may still be made, showing that the beak has not engaged in the fixed portion of the urethra. The patient may also complain of pain.

The following manipulation may be used to overcome the difficulty: The entire instrument may be raised vertically toward the pubes. This will often permit the beak to ride over the obstruction and enter the membranous urethra. The same end may sometimes be accomplished by upward pressure against the convex portion of the sound with the forefinger and thumb placed against the perineum. No force is permissible, since it is here that false passages are created with the greatest frequency by rough manipulation. The beak of the sound having once engaged in the membranous urethra, rotary motions of the shaft are no longer possible. If obstruction is met with beyond this point, it will be due to a deformity of the prostatic urethra, accompanying prostatic hypertrophy, more often than to any other cause. A forefinger introduced into the rectum will show the exact position of the instrument. In normal cases, when the beak has engaged in the fixed portion of the canal, all that is necessary is to rotate the shaft slowly downward to the horizontal, when the instrument will glide readily into the bladder.

FIG. 147.—THIRD STAGE IN THE PASSAGE OF A SOUND. In most instances it will then be sufficient to continue the rotation beyond the vertical and gradually to sink the shaft downward between the patient's thighs. In some cases it is of advantage, as described in the text, to apply the fingers of the other hand to the perineum. (After Watson and Cunningham.)

We may be certain that the instrument has entered the bladder by the free rotary mobility of the shaft upon its long axis.

The examination of the bladder should be conducted in a systematic manner. In order to preserve the necessary delicacy of touch, the handle of the searcher should be held like a penholder, lightly, between the finger and thumb of the right hand. To determine whether the form of the bladder is symmetri-

cal or not, the instrument is pushed on into the middle of the bladder and held exactly in the median line. The handle is then rotated first to one side and then to the other. If the bladder is nearly or quite empty, and symmetrical, we can turn the searcher through an equal arc on either side. A rectum distended with feces may limit the space on the left. If the bladder is asymmetrical we may be able to turn the searcher in one direction only. We next

FIG. 148.—THE FOURTH STAGE IN THE PASSAGE OF SOUND. The sinking of the shaft may often be facilitated and the tension of the tissues made less by relaxation of the suspensory ligament of the penis. This is accomplished as shown in the figure by pressing downward and backward the tissues which overlie the symphysis pubis. (Keyes.)

test the softness or rigidity of the bladder by pushing the searcher upward and backward, until it comes into contact with the posterior bladder wall. A normal bladder is soft and easily stretched by the sound; a bladder thickened from muscular hypertrophy or a bladder the seat of chronic inflammatory infiltration is hard and unyielding. After testing the accessible portions of the bladder wall, the instrument is withdrawn until the beak is close to the symphysis, and the effort is made to rotate it completely around upon its long axis. If the prostate is normal this will not be possible, unless the shaft of the instrument is depressed below the horizontal. In cases of enlarged prostate quite a deep pocket may be formed just behind the prostate; and whereas, the bladder being nearly empty, we have been unable to complete the rotation in the middle of the bladder; we may find that just behind the prostate such rotation may be made with ease.

It is in this pocket that small stones are apt to lie. With the searcher in this position we may sometimes feel the bulging inequalities of surface, produced by the unequal enlargements of lateral or median lobes of the prostate.

In hypertrophied and trabeculated bladders the prominent ridges and intervening depressions arrest the beak of the searcher in its passage along the lateral walls of the bladder, and thus we are enabled to recognize these conditions. Firm tumors of the bladder may be recognized in a similar way; though the sensations transmitted to the hand are rarely definite enough to enable us to make a positive diagnosis.

(For the technic of sounding for stone, see Vesical Calculus.)

Testing the Sensation of the Bladder.—The sensitiveness or anesthesia of the different portions of the bladder may be tested with the searcher. Normally, the trigonum is the most sensitive portion of the bladder. In cases of posterior urethritis due to gonorrhea, the trigonum of the bladder is the portion chiefly involved, its sensitiveness is markedly increased, so that the patient may scream with pain as the instrument passes over it. In cases of diffuse cystitis the entire bladder wall is highly sensitive. Ulcerated areas, notably tuberculous ulcers, are exquisitely painful when touched by the sound, and the same may be true of tumors of the bladder, the more so if ulcerated.

In certain diseases of the spinal cord, and after injuries of the cord, there may be partial or complete anesthesia of the bladder.

The Sufficiency of the Bladder.—To test the sufficiency of the bladder, the patient empties his bladder as completely as possible. A catheter is then introduced into the bladder and the remaining urine drawn off. Its quantity represents the degree of insufficiency. The normal bladder empties itself almost completely, so that a dry tap results, or at most, but a few drops of urine escape from the catheter. The procedure is best performed with the patient standing erect and with a soft catheter. The bladder cannot be so completely emptied with a metal catheter and the patient supine. When exploring an insufficient bladder, after the patient has urinated, we find that the searcher can still be moved about with greater or less freedom in its interior, demonstrating that the bladder is not empty. The *residual urine* will vary in quantity from a few drachms to many ounces. Ultzmann considered that if the quantity exceeded 300 to 400 c.c. the bladder was to be regarded as paretic rather than merely insufficient.

(For direct inspection of the interior of the bladder through a straight tube, see Kelly's Method of Examining the Bladder, also Catheterization of the Female Ureters.)

Cystoscopic Examination of the Bladder.—(For description of instruments and technic, see Cystoscope.)

Though the cystoscope has its limitations, and in some cases cannot be used at all, it has largely displaced other methods of examining the interior of the bladder, since the information obtained is so much more definite than that gained with the searcher, and so much less dangerous than suprapubic or perineal incision. The former gives, of course, very positive information, and affords opportunity to operate radically; but it is a serious operation in itself, and is scarcely used at present as a merely diagnostic measure. Perineal inci-

[illegible], the finger being used to dilate the prostatic urethra, is a serious procedure, but affords a good opportunity to palpate the bladder. When the prostate is large and hard it is not practicable, unless the prostate be first removed.

The cystoscope cannot be used in cases of tight stricture of the urethra. When the prostate is greatly enlarged. When the bladder is contracted. When active hemorrhage is going on from the bladder wall, and is difficult, or contraindicated in some other conditions to be mentioned.

The appearances of the normal and of the diseased bladder in the cystoscopic field are best learned by practical experience. Some of them have already been described in the sections on the cystoscope, notably the appearances of the ureteric orifices. The color of the mucous membrane of the normal bladder as seen in the cystoscope is a pale reddish-yellow. Arterial branches can be seen here and there shimmering through its surface.

Cystitis gives a very variable picture. In acute cases the mucous membrane is notably reddened. Clumps and particles of muco-pus may be seen clinging to its surface. In chronic cystitis the mucous membrane is thickened and swollen, not notably red. The character of the secretion is apt to be more tenacious.

The early lesions of bladder tuberculosis are apt to be most evident in the trigonum and around the mouths of the ureters. In some cases the condition cannot be distinguished from ordinary cystitis, in others groups of tubercles or tuberculous ulcers may be recognized.

Trabeculated and sacculated bladders, as well as encysted stones, are all readily seen and recognized.

In cases of prostatic hypertrophy it is necessary to use a retrospective cystoscope in order to get a proper view. Such cystoscopes are now made in

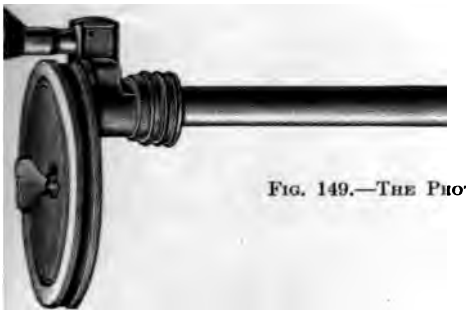


FIG. 149.—THE PHOTOGRAPHIC CYSTOSCOPE OF NITZE.

the city of New York by the Wappler Brothers, which fulfill the indication. (See Cystoscope.) The swollen collar of prostatic tissue projecting into the bladder may then be seen, or a knob, the enlarged middle lobe. The depth and contents of the retroprostatic pocket may also be studied. (See also Vesical Calculus and Tumors of the Bladder.)

THE PHOTOGRAPHIC CYSTOSCOPE.—The photographic cystoscope made by Hartwig, Berlin, consists of a long prismatic cystoscope of rather large caliber,

Nos. 25 to 26 French. At the ocular end of the instrument is a movable eyepiece, so arranged that in one position the surgeon can view the interior of the bladder, and bring the stone, tumor, or other lesion into the field of the instrument. The instrument is then firmly fixed in position, and held immovable by a series of steel rods and clamps fastened to the table. The eyepiece is then moved into a second position, thus exposing a small photographic plate to the illuminated image of the interior of the bladder.

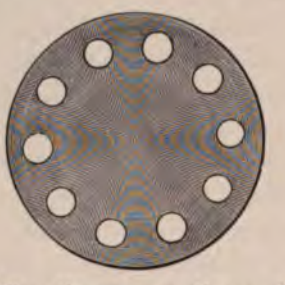


FIG. 150. — PERFORATED METAL PLATE AT THE OCULAR END OF THE PHOTOGRAPHIC CYSTOSCOPE; BY THE ROTATION OF WHICH TEN SUCCESSIVE PICTURES OF THE INTERIOR OF THE BLADDER MAY BE MADE. (Watson and Cunningham.)

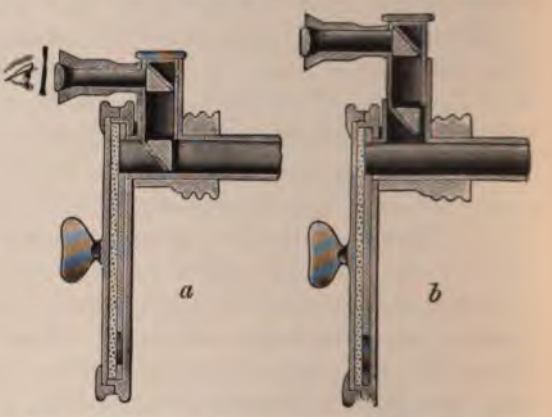


FIG. 151.—OCULAR PORTION OF THE PHOTOGRAPHIC CYSTOSCOPE. The position of the prisms at *a* is that for viewing the interior of the bladder. At *b* the position is that for taking a photograph, the prism is drawn out of the caliber of the instrument, thus exposing the photographic plate. (Watson and Cunningham.)

FIG. 152.—CYSTOSCOPIC PHOTOGRAPH OF A PHOSPHATIC STONE IN THE URINARY BLADDER TAKEN BY THE LATE DR. W. K. OTIS.

FIG. 153. — DILATED URETERIC ORIFICE; CYSTOSCOPIC PHOTOGRAPH TAKEN BY THE LATE W. K. OTIS.

The photographic plate is circular (see Fig. 150). By turning a small thumbscrew, successive exposures of different parts of the plate may be made, to the

number of ten. The exposures vary from five to twenty seconds in length. The plate is developed in the dark room, in the usual way, and the minute negatives are placed in a camera having a very long bellows (five feet or more), and enlarged to a diameter of an inch, or larger. Very accurate pictures may thus be made of stones, tumors, diverticula, abnormalities of the ureteric papillæ, etc. Some of the photographs in the text were made by the late William K. Otis. They are valuable and interesting records. A good deal of time and pains are necessary to make them, and their production will probably remain in the hands of enthusiastic specialists.

THE CONGENITAL DEFECTS OF THE BLADDER

Exstrophy of the Bladder—Ectopia Vesicæ.—Exstrophy of the bladder is a congenital defect, the diagnosis of which is to be made by inspection. It therefore requires no very lengthy description here. In children born with this defect the anterior abdominal wall and the bladder have failed to unite in front; there is a similar failure of union of the lateral pelvic bones at the symphysis pubis, and the cleft in the male is continued through the urethra and external genitals. Upon inspection, the posterior wall of the bladder forms a bulging, red tumor, covered with mucous membrane, between the umbilicus at its upper border and the urethra below. The penis is smaller than normal; the open urethra lies on top of it (epispadias). In the female there may be no urethra, the clitoris is split, the labia are wide apart.

Fig. 154.—Exstrophy of the Bladder. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

By pushing back the bladder the ureteral orifices can be seen near its lower border, and from them acid urine constantly escapes. The deformity is three times as frequent in the male as in the female. The condition is quite commonly associated with inguinal hernia, frequently double, and usually of the scrotal type.

In all these cases cystitis soon develops with ammoniacal decomposition. The urine produces eczema and excoriation of the surrounding skin, the odor given off is disgusting in the extreme, so that the individual is truly in a

pitiable condition. Incomplete forms also exist. In the first group, superior fissure of the bladder, an opening exists in the upper part of the bladder. The symphysis and external genitals are normal. (See also Urachus Fistula.) In the second group, inferior fissure of the bladder, an opening exists below the symphysis, which is united, though not firmly. In the female, anomalies of the uterus, ovaries, and vagina usually coexist. Prolapse of the rectum is often present.

Double Bladder, Bilocular Bladder, Congenital Diverticulum of the Bladder.—Failure of union on the part of the two sides of the embryonic allantois may produce in the fetus a double bladder with a ureter opening into each. The defect is usually associated with others, of such character that the child is not viable. A partial failure of union produces a bilocular bladder with a more or less complete median septum. Congenital diverticula of the bladder, and bladders constricted in one diameter are occasionally observed. Such diverticula may be of considerable size, and may become the seat of infectious processes. The diagnosis of these conditions in the adult can best be made with the cystoscope.

CHAPTER XXIV

INJURIES OF THE BLADDER

Injuries of the bladder are more frequent when the bladder is full than when it is empty. When distended, the bladder, as stated, rises out of the pelvis, and is exposed to direct injury through the abdominal wall. In a large proportion of cases injuries of the bladder are associated with fractures of the pelvis.

For purposes of description injuries of the bladder may be divided into subcutaneous injuries, including ruptures, and into open wounds. A third group includes injuries produced by sounds, lithotrites, and other instruments introduced through the urethra.

RUPTURE OF THE BLADDER

Rupture of the bladder is not a very common accident. It occurs most often in male adults, occasionally during childhood and in old age. It is far more common among men than among women, nine to one (Bartels).

In Bartels' collected cases of rupture of the bladder, 169 in number, 109 were complicated by fracture of the pelvis. In 30 cases there were multiple fractures. In 22, there was diastasis of the symphysis pubis. In 11, separation of the sacro-iliac joint. In 27, fracture of the os pubis. In 12, fracture of the ischium. In 9, fracture of the ilium. In 5, fracture of the sacrum and os pubis.

Fracture of the pelvis, notably of the descending ramus of the pubes and ascending ramus of the ischium, is frequently complicated by rupture of the bladder. In some of these cases the distended bladder is burst from sudden pressure, in others the bony fragments penetrate the bladder wall. The latter accident may happen when the bladder is empty.

In the class of cases complicated by fracture of the pelvis the causes are falls from a height, crushing injuries, as, for example, run-over accidents, falls from a horse in the hunting field, notably when the horse falls upon the man; compression of the body between the buffers of railway cars, and the like. In the majority of these cases the rupture is extraperitoneal. In another group of cases a tear occurs, separating the prostate from the bladder, or tearing across the membranous urethra at the apex of the prostate. The distended bladder may also be burst by blows or falls upon the front of the abdomen,

as the blow of a fist, the kick of a horse, or when an individual falls and strikes the suprapubic region against a projecting obstacle. These cases are usually intraperitoneal ruptures, the mechanism being that the distended viscus is compressed against the promontory of the sacrum.

Falls from a height upon the buttocks may rupture the bladder.

In a few cases the bladder has been ruptured by overdistention with water during the operations of litholapaxy or suprapubic cystotomy.

Predisposing Causes.—As predisposing causes of rupture may be mentioned disease of the bladder wall, chronic and acute alcoholism, the last since a man who is very drunk is apt to have a distended bladder and is likely to meet with an accident.

Character and Situations of the Lesions.—Rupture of the bladder may be complete or partial. The *partial ruptures* involve the mucous membrane and a portion of the muscular coat. They usually get well of themselves. The *complete ruptures* are among the gravest of injuries. The tears may be intra- or extraperitoneal, the former being more common. The *intraperitoneal ruptures* occur at the apex of the bladder or on the posterior wall. The *extraperitoneal ruptures* more often on the anterior wall of the bladder. The tears may be vertical or transverse; in the latter case they gape but little. In some cases the tear is a straight line; in others, as in one of my own cases, angular, or L-shaped; in others the rent looks more like a loss of substance than a tear. The size of the rent varies from half an inch to several inches in length. When the rupture is of some size, and intraperitoneal, the bladder empties itself into the peritoneal cavity, with the production of a fatal, putrid, or purulent peritonitis. Aseptic urine may be absorbed by the peritoneum without the production of peritonitis. Theoretically, spontaneous recovery from intraperitoneal rupture of the bladder is thus possible; practically such recovery may be disregarded. Even if no germs were present in the circulating blood, instrumentation of the urethra and bladder would furnish them. Peritonitis is, however, delayed in some cases, and may not develop for several days. If the tear is small, an encapsulated abscess is a possible though rare event.

When the rupture is extraperitoneal the urine infiltrates the loose connective tissue around the bladder, first into the space of Retzius above and in front of the bladder, and causes the necrotic inflammation peculiar to extravasation of urine in connective-tissue planes. Such an inflammation may spread from the bladder upward to the kidneys and downward to the knees.

I recall a case seen at Bellevue Hospital when I was a member of the interne staff:

A man fell into the hold of a ship and was brought to the hospital in a condition of shock. Among other injuries he had a fracture of both the horizontal and descending ramus of the pubic bone of one side, and a diastasis of the symphysis pubis. The anterior wall of his bladder was torn or ruptured. The injury of the bladder was not recognized until extensive extravasation had occurred, followed by a rapidly progressive putrid cellulitis, which extended to the free border

of the ribs in the left flank, involved the loose connective tissues of the pelvis and the subcutaneous tissues of the anterior abdominal wall, the scrotum, the perineum, and the anterior surface of both thighs. A perineal drainage of the bladder was made and extensive incisions elsewhere. He died, oddly enough, not of the direct effects of sepsis, but from a secondary hemorrhage from the perineal wound, some three weeks after the injury.

In certain cases of rupture of the bladder the tear occurs in a part covered by peritoneum, but involves the mucous membrane and muscular coat merely. The urine then spreads beneath the peritoneum with greater or less rapidity, according to the size of the tear, and results, as in the extraperitoneal ruptures, in diffuse necrotic cellulitis, sometimes in a localized urinous abscess, sometimes in purulent peritonitis.

Symptoms of Rupture of the Bladder.—Since rupture of the bladder usually occurs from extreme degrees of violence, and is often associated with fracture of the pelvis, *shock* is usually marked. The shock may endure till death, the patient never reacting. In other cases shock will be less marked, and the patient will suffer from *a constant desire to urinate, from extreme pain referred to the bladder or lower part of the abdomen, and from either total inability to urinate, or, if able to urinate at all, a small quantity only of bloody urine will be passed.* The presence of these symptoms is very constant. In addition there may be nausea and vomiting, and after hours or days the signs of acute peritonitis, septic symptoms, etc.

Upon introducing a catheter, it may pass readily into the bladder, but a few drops only of bloody urine, or nothing, will escape. The bladder is empty. If a long catheter is used it may, if of metal, after entering the bladder pass through the rent into a considerable cavity and permit the escape of a quantity of urine and blood. If a catheter be introduced into the bladder, and salt solution in measured quantity injected through it, none, or a diminished quantity, may return. This sign is presumptive evidence of rupture of the bladder. It should, however, be borne in mind that the catheter may be in the peritoneal cavity, and the injected fluid may have returned thence. In regard to the injection test the following pertinent remarks are quoted from Samuel Alexander (*Annals of Surgery*, August, 1901, "Intraperitoneal Rupture of the Bladder," etc.):

> The injection test is not only unreliable, it is also likely to spread infection throughout the peritoneum. When used, it should be only after the patient has been prepared for immediate operation and is upon the table. I believe that it is more than probable that it has been a cause of peritonitis in some patients who otherwise would have escaped. An additional objection to this test is that in patients already exhausted and shocked, the pain which it causes is likely to weaken their vitality and lessen their resistance. Of the inflation test I have no personal experience. Mr. Walsham says, as we might expect, that when the intestines are tympanitic it is unreliable. The injection of air into the peritoneal cavity would, I think, be likely to cause in some cases dangerous syncope, and

possibly a fatal result. But I do not see the necessity to make an absolute differential diagnosis between an extra- and an intraperitoneal rupture. Both injuries require immediate operation, and in my opinion both require incision of the abdominal wall. It seems to me to be a simple matter in cases of doubt to begin by exploring the prevesical space through a suprapubic incision.

Upon palpation of the abdomen after rupture of the bladder, the patient will usually scream with pain when pressure is made above the symphysis pubis. In some cases of extraperitoneal rupture it is possible to feel a tense mass behind the symphysis pubis. In some cases of intraperitoneal rupture the signs of free fluid in the belly have been observed, notably if the patients have survived several days without operation. When the bladder has been *ruptured* by the *injection of water previous to operation*, the characteristic bladder tumor has suddenly disappeared, and catheterism has found the bladder empty or nearly so.

Differential Diagnosis.—The following points may aid in the differential diagnosis between rupture of the bladder, rupture of the kidney, and rupture of the urethra.

In rupture of the kidney there will be a history of an injury to the loin or upper part of the abdomen. The patient is usually able to urinate, or if not, a catheter is easily introduced into the bladder, and in either case the urine obtained is evenly mixed, with much or little blood.

If the renal pelvis or ureter are *plugged* or *completely torn across*, the signs in the kidney region—i. e., pain, tenderness, and later the development of a tumor—will usually be marked. The catheter will withdraw from the bladder clear urine, or urine containing very little blood. The pain and tenderness will be largely in the kidney region or will resemble renal colic. Unless the bladder comes to be distended with blood clots, a rather unusual event after rupture of the kidney, there will be no constant desire to urinate. In *rupture of the bladder* there will be a history of an injury to the suprapubic region, or a fracture of the pelvis. The patient has a constant desire to urinate, but cannot do so. In a few cases after violent straining a small amount of urine mixed with blood is passed. There are severe continuous pain and tenderness over the bladder. A catheter is easily introduced, and a dry tap is the result. *In rupture of the urethra* there is usually a history of an injury to the perineum, sometimes fracture of the pubis or ischium. Swelling and ecchymosis of the perineum and scrotum appear after a few hours. There is retention of urine. A catheter meets with obstruction, and can rarely be made to enter the bladder.

While in many cases the diagnosis of rupture of the bladder is simple, from the history, and the signs and symptoms as described, such is not always the case, nor are we always able to differentiate before operation between intra- and extraperitoneal ruptures. In some cases the patient has been able to urinate after the accident, and peritonitis, or urinary infiltration has first

called the attention of the surgeon to the character of the injury. In these cases it seems probable that the rupture has been incomplete at first, and has later become complete.

A sign of intraperitoneal rupture of the bladder is sometimes obtainable which is quite positive. It is as follows: If a metal catheter be introduced into the bladder and through the rupture into the peritoneal cavity, its point can be moved about in the abdomen with more or less freedom, and may be felt immediately beneath the abdominal wall. Though this sign might be present in a case of retention of urine, the two conditions are not likely to be confounded.

Treatment of Rupture of the Bladder.—Immediate operation and suture of the wound in the bladder is the only treatment which offers a reasonable hope of saving life. Accuracy in suturing has much to do with the prognosis in cases of intraperitoneal rupture. If operation is done within an hour or two, and the suturing is secure, *drainage* of the peritoneum might be omitted. I prefer to use it.

In extraperitoneal cases the external wound should be drained down to the bladder. Drainage of the bladder itself, or its omission, does not appear to have materially modified the results in the reported cases. Quick, in a recently reported case, operated successfully two hundred and fifty-four hours after the injury (a unique case); there was no peritonitis. Wounds in bladder closed by silk sutures. Bladder drained for five days through a catheter. Uneventful recovery.

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OPEN WOUNDS OF THE BLADDER

Stab and Punctured Wounds of the Bladder.—Stab and punctured wounds of the bladder may pass through the abdominal wall or through the perineum; the latter are sometimes impalements, from falls on sharp sticks, a picket fence, or the like. The horn of a bull may produce such an injury. These are more common than injuries from pointed weapons. The wound often involves the rectum in males, the vagina or rectum in females. In a few cases the wounding body may pass through the obturator foramen.

Signs and Symptoms.—In stab or punctured wounds above the pubes, the situation of the wound, and the escape of urine mixed with blood establish the diagnosis. If the wound be narrow, or pass through the peritoneal cavity, no urine may escape externally. The history of these cases would present the same sequence of events as are seen after rupture—i. e., peritonitis or putrid cellulitis. In wounds through the perineum, since they are usually caused by blunt objects, and are the result of great violence, shock will usually be marked. The patients will complain of intense vesical tenesmus; if the rectum is also injured, of rectal tenesmus as well. The escape of urine from the wound renders the diagnosis certain. If the peritoneum is wounded, putrid peritonitis will occur; if not, and the external wound is small, infiltration of urine into the connective-tissue planes of the pelvis, or into the space of Retzius, or into the perineum, depending upon the situation of the injury. If the wound is a simple stab or puncture into the fundus of the bladder, and the external wound is large, so that urine may freely escape, spontaneous healing is possible. In many cases a fistula will remain, which may be hard to close. If the wound is small no leakage may take place for some days; the wound edges may then slough; leakage and urinary infiltration will then occur.

Gunshot Wounds of the Bladder.—Gunshot wounds of the bladder occur in battle with considerable frequency. The bladder may be penetrated in any direction, and the wounds are commonly associated with fractures or perforation of the pelvic bones and injuries of other abdominal viscera. In some cases bone fragments, pieces of cloth, or a projectile have remained in the bladder and become the nucleus of stone.

Diagnosis.—In gunshot wounds of the bladder the diagnosis can less often be made by the escape of urine from the wound than is the case with widely open wounds from knives, or punctures with blunt objects. The wound canal is often too narrow, and the bullet wounds in the bladder itself if made by a small-caliber bullet at long range may be no larger than the diameter of the bullet. Such a wound may contract so much after some urine has escaped that it ceases to leak. It is believed that in the Boer War instances occurred of bullet wounds of the bladder which healed spontaneously. If, however, the bladder is distended, and the bullet strikes it when moving at high velocity, the explosive effect may be marked. The bladder may be rent in all directions. Such wounds do not come under treatment. The simpler bullet wounds of the bladder may run one of several courses. The wound may heal spontaneously without infiltration. The wound may permit the external discharge of urine from the first, and either heal or leave a fistula. The wound may not leak at first, and later, after some days, give rise to urinary infiltration, sepsis, and death. The associated injuries modify the prognosis in any case. A probable diagnosis may be made from the situation of the wound or wounds. If there be a wound of exit, it is to be remembered that the course of a high-powered rifle bullet through the body is usually straight, irrespective of the tissues perforated. (See also The Diagnosis of Rupture of the Bladder.)

Accidental Wounds of the Bladder during Surgical Operations.—As elsewhere stated, the bladder has been opened, even extirpated, by surgeons of experience, on the mistaken assumption that it was a cystic tumor. To avoid this error, it is incumbent upon the surgeon to satisfy himself that the bladder is empty by seeing a catheter introduced upon the operating table. This is far safer than taking the words of others for a fact.

During the removal of pelvic tumors the bladder has occasionally been cut, torn, or a portion of its wall included in a ligature. This has happened more often during the removal of adherent malignant tumors from the female pelvis than in other cases. The diagnosis can usually be made at the time by the escape of urine, and the characteristic appearance of the bladder wall. The accident can be avoided by keeping a steel sound in the bladder during the dissection and the occurrence may be recognized by the same means. (See also Hernia of the Bladder and the Operations for Hernia.)

The injuries of the bladder occurring during natural or instrumental delivery of women belong to the domain of gynecology rather than of surgery. They can be readily recognized by introducing a speculum into the vagina, and injecting a solution of argyrol into the bladder through the urethra. The

brown stain of argyrol seen at the orifice of the fistula is characteristic. *Vesico-rectal fistulæ* are described under Intestinal Fistulæ.

FOREIGN BODIES IN THE BLADDER

Foreign bodies gain access to the bladder in a variety of ways: A bullet may lodge in the bladder, or a portion of clothing or bone, or other material may be carried into the bladder by a bullet. A foreign body may ulcerate into the bladder from the intestine or from the peritoneum. A foreign body may cause a punctured wound of the perineum or abdominal wall, enter the bladder, break off, and a portion of it remain behind. Such may be sticks, branches of trees, pointed metal objects, etc.

FIG. 155.—GAUZE PAD ENCRUSTED WITH PHOSPHATES, REMOVED BY THE AUTHOR THROUGH A SUPRAPUBIC INCISION FROM THE BLADDER OF AN OLD MAN WHOSE PROSTATE HAD BEEN REMOVED BY THE PERINEAL ROUTE IN ANOTHER HOSPITAL SOME MONTHS BEFORE. (New York Hospital, author's service.)

I removed, some time ago, a thick gauze pad some four inches square from the bladder of an old man, upon whom the operation of perineal prostatectomy had been done by another surgeon six months before. The patient had suffered a good deal and had a putrid cystitis. The pad had become thickly encrusted with phosphates and felt like a large, soft stone when struck with the searcher. The old man felt better after the gauze had been removed, through a suprapubic incision. A photograph of the gauze is shown (Fig. 155). I prefer not to mention the name of the surgeon.

Lastly, foreign bodies enter the bladder through the urethra. Such may be portions of old and rotten catheters, filiform bougies, etc., or they may be bodies of the most varied description, introduced by individuals from perverted sexual motives. The latter class of accidents is much more frequent among women than among men. The female urethra is so short that a foreign body readily enters the bladder, and may slip out of the fingers and be lost. Among such bodies may be mentioned hairpins, pencils and penholders,

sticks of sealing wax, chewing gum, beads, bullets, or shot, straws, feathers, thermometers, and glass rods or tubes. From the bladders of women, thermometers are sometimes removed. The instrument is introduced for the purpose of taking the temperature, and is slipped into the urethra instead of the vagina. The thermometer finds its way into the bladder, where it remains until extracted. In cases of extra-uterine pregnancy fetal bones have ulcerated through the bladder wall and have formed the nucleus of stone or given rise to severe cystitis. Among males, foreign bodies in the bladder are less frequent but are not very rare. The body is introduced through the meatus into the urethra, and is pushed on until the outer end slips from the grasp of the fingers. Unskillful efforts to extract it may result in pushing it deeper, until it enters the bladder. In two cases seen at the Roosevelt Hospital chewing gum was found as the nucleus of the stone. I recently removed a large vesical calculus from the bladder of a young man, the nucleus of which was a large open safety pin, the pointed limb of which was free (see Fig. 156). The patient was a deaf-mute boy aged seventeen, who could not or would not admit any previous knowledge of the pin. He had the signs and symptoms of a severe cystitis. An X-ray picture showed the presence of the stone and of the pin. They were removed by a suprapubic cystotomy. It seems probable that the pin was introduced closed, and was opened by the patient during his efforts to extract it, and that the point being forward the pin found its way into the bladder.

FIG. 156. — STONE REMOVED FROM THE URINARY BLADDER OF A YOUNG MAN, CONTAINING AN OPENED SAFETY PIN AS A NUCLEUS. (New York Hospital, author's service.)

Pieces of rotten rubber catheters are the most common variety of foreign bodies found in the male bladder. They were broken off during catheterization. The patients are old men with enlarged prostates, or others who are obliged to use a catheter habitually. Even this accident is not a very common one. In the records of the New York Hospital I find but one such case recorded since 1890. Dr. J. R. Hayden informs me that he has seen but one. I recall only one such case in my own experience. The patient was an old man, a prostatic, who developed stone in the bladder, the nucleus of which proved to be a piece of a red rubber catheter. He had no knowledge of how it got there.

When a foreign body remains in the bladder the lesions and symptoms produced will vary with the shape and size of the body, and to some extent will depend upon whether it is aseptic or not. Small, smooth, rounded

bodies—a glass bead, for example—might remain in the bladder and cause only mechanical symptoms, such as interruption of the stream of urine. Sharp and irregular bodies may cause pressure ulceration, and even perforation, with infiltration of urine. Needles are apt to become partly embedded in the bladder wall.

FIG. 157.—CYSTOSCOPIC PICTURE OF A HAIRPIN IN A YOUNG GIRL'S BLADDER. (Nitze.)

Cystitis.—Cystitis in most cases soon develops. The foreign body is rapidly incrusted with earthy and ammonio-magnesium phosphates and becomes the nucleus of a stone. If the bladder is already the seat of cystitis, such a formation may occur very rapidly, so that the stone will grow to a large size in a few weeks. The cystitis produced by foreign bodies often becomes putrid or even gangrenous in character.

The Position Taken by Foreign Bodies in the Bladder.—Heavy bodies—metal, glass, etc.—naturally lie in the fundus. Light bodies—wax, wood, etc.—tend to rise to the apex. A long, slender body, if not more than three inches in length, tends to assume a transverse position; if longer, a vertical one.

Subjective Symptoms.—The subjective symptoms produced by foreign bodies vary. If the body is small, clean, round, and smooth, subjective symptoms may be trifling or absent. If the body is sharp, rough, and infected, the symptoms are those of an intense cystitis, to which are added severe spasmodic pain when the inflamed bladder closes down upon the incrusted body. Owing to the greater sensitiveness of the prostate and trigone, the pain is apt to be more severe in men than women. In general, the symptoms are those of acute cystitis and of vesical calculus.

Diagnosis.—The history will render the diagnosis clear in some cases. In others the patient will hide the true condition through shame. Examination of the bladder with a searcher will reveal the presence of a large, hard, foreign body at once. If the body be small—a shot or a needle, for example—it may be missed. Soft foreign bodies, such as chewing gum, may be difficult or impossible to detect by this means until they have become incrusted with salts.

The cystoscope gives the best results; the character and situation of the body can be seen clearly. In women, Kelly's tubes may be used. Foreign bodies of metal or glass are readily detected by the X-rays. Stereoscopic radiographs will show the direction of the long axis of a slender body, with reference to the axes of the bladder itself. In women, for want of a better means of diagnosis the urethra may be dilated and the bladder explored with the finger.

CHAPTER XXV

THE URINE

EXAMINATION OF THE URINE WITH ESPECIAL REFERENCE TO DISEASES OF THE BLADDER

The technic of a complete urinary analysis has become so elaborate that no surgeon attempts to do it himself. A well-equipped laboratory is essential, and a man must be a highly skilled chemist, as well as a good pathologist and microscopist, in order to do the work well. A full description of the technic would require a separate volume to do it justice. The results being given, it rests with the surgeon and clinician to interpret their bearing upon the individual case, and in the following section more attention will be given to the diagnostic value of urinary findings than to technic. In addition, certain of the simpler tests and methods of examination will be described, such as the surgeon can make for himself. It is well for young surgeons to bear in mind that very good work can be done with very simple apparatus, and that the surgeon who comes to rely greatly on laboratory findings for diagnosis and therapeutic indications may become neglectful of important data obtainable by the careful use of his own senses, to the impairment of his own diagnostic skill and judgment and to the detriment of his patient.

In the following section I am especially indebted to the works of Ultzmann, Guyon, Sonnenberg, and Blumenthal.

Daily Quantity of Urine.—The daily output of urine of a healthy, temperate adult averages about 1,500 c.c., or 50 ounces. It is greatly modified by the quantity of water taken, and varies with the habits of the individual in this regard; further, with the amount of physical exercise, and consequent rapid elimination of water through the skin and lungs. Many diseases also affect both the quantity and specific gravity of the urine. Diseases attended by profuse sweating (night sweats of phthisis) diminish the quantity of urine. In fevers the quantity of urine is small. During convalescence from fever, *polyuria* is common. Badly compensated heart lesions, chronic diffuse nephritis of the parenchymatous type, and acute nephritis, including scarlatinal nephritis, are accompanied by *oliguria*. In diseases accompanied by general anasarca and by transudates of watery fluid into large cavities—ascites and hydrothorax, for example—oliguria is sometimes marked. Hysterical women often feign either inability to urinate or anuria.

In every case of doubt as to whether suppression or retention exists, a

catheter will solve the problem at once, and should always be used. Especially should the surgeon be on his guard lest he mistake the condition known as *ischuria paradoxa* for urinary incontinence, or oliguria. It is a mistake often made. In this condition the bladder is distended, but the patient cannot empty it. A little urine, only, dribbles away from time to time. One sees this condition of *retention with overflow* in acute febrile disease, when the patient is very weak, in prostatic enlargement, in injuries and diseases of the spinal cord, and in unconscious patients. The distended bladder is readily made out on palpation and percussion above the pubes, and a catheter passed into the bladder withdraws a large quantity of urine. Among other conditions causing *oliguria* may be mentioned diarrhea, weakness and degeneration of the heart muscle, abdominal pain, eclampsia, and lead colic. Among the conditions which produce an increased quantity of urine—*polyuria*—may be mentioned the use of diuretics; the rapid absorption of transudates (edema, ascites, hydrothorax); also diabetes mellitus and insipidus, tuberculosis of the kidney, neurasthenia (urina spastica), chronic interstitial nephritis (granular kidney), convalescence from infectious diseases, epilepsy, hysteria, Graves's disease, diseases of the cerebellum, and some diseases of the spinal cord.

Color of the Urine.—The normal color of the urine is a bright, clear amber or a wine yellow. Various conditions and diseases may change its color. Fever renders the urine darker—orange-red or yellowish-red. The urine of jaundice is the color of dark beer. In chyluria the urine is milky white. During menstruation the urine has a light bloody tinge. If larger quantities of blood are present the urine varies from blood-red to black, if the blood is old. The urine, after large doses of carbolic acid, guaiacol, creosote, resorcin, naphthalin, is greenish, or smoky, or dark brown. Methylene-blue renders the urine dark blue. Trional and sulphonal sometimes render the urine a red-wine color. Dark brown and black urines are observed in some severe cases of malarial fever (black-water fever) and in advanced cases of melano-sarcoma. Indigo-uria may furnish a dirty blue urine. Senna, rhubarb, and santonin may produce golden-yellow urine; if alkaline, red. Putrid urine in gangrenous cystitis may have a greenish fluorescence (Blumenthal).

In diseases of the bladder the urine remains normal in quantity, as a rule, as well as in specific gravity—1.018 to 1.022. In diseases of the kidneys, on the other hand, both the quantity and the specific gravity of the urine usually depart widely from the normal. This is particularly true of chronic interstitial nephritis, where polyuria and a diminished specific gravity are the rule. In the end stages of chronic renal disease, on the other hand, and in acute nephritis, oliguria, and even total suppression of urine, are to be expected.

Thus, in the presence of *chronic* disease of the bladder, if the *quantity* and *specific gravity* of the urine remain *normal*, it is probable that the kidneys are healthy; if, on the other hand, the bladder is diseased, and the patient has *polyuria* with a *low specific gravity*, the kidneys are probably the seat of nephritis.

In estimating the functional activity of the kidneys, especially with reference to the daily output of *urea*, the most important constituent of the solid ingredients of the urine, it is necessary to collect and measure the twenty-four-hours' urine, and to examine a sample of the mixed specimen. In order to do this the urine is collected in a suitable bottle and measured. The patient is told to empty his bladder at a certain hour and to discard this specimen. All the urine passed during the next twenty-four hours, including the urine voided at the end of that period, is collected, and constitutes the output of the kidneys for one day.

Reaction of the Urine.—The reaction of the urine is normally acid. The reaction is tested by litmus paper or tincture of litmus, in the generally known manner. A meat diet and exercise tend to render the urine more acid, as does the internal administration of benzoic acid. A vegetable diet, milk, alkalies, and vegetable acids, render it less acid or alkaline. (See also Cystitis.)

Opacity of the Urine.—Normal urine is clear and transparent when first passed. After standing for some hours, a faint cloudy sediment forms, the so-called mucous cloud, which may hang in the center of the vessel or sink to the bottom. It is more marked in the urine of females. In diseases of the bladder the urine is usually cloudy and opaque from the presence of pus and other abnormal ingredients. Alkaline urine may be opaque from precipitation of earthy phosphates or carbonates; the latter usually when the individual has been drinking alkaline mineral waters or taking alkalies in other forms. Both these precipitates disappear on adding acetic acid or other acid to the urine, the carbonates with marked effervescence. The opacity due to phosphates and carbonates is increased by heating, but disappears upon adding an acid. The opacity due to pus in the urine, on the other hand, is increased by heating, and remains unchanged on adding an acid. Phosphaturia may occur in nervous individuals, and among those who are taking much milk or other food or drink such as renders urine alkaline. Urine allowed to stand in a cold place in winter, if concentrated, *becomes muddy and opaque from precipitation of uric-acid salts.* These are redissolved upon heating.

The opacity due to *bacteriuria* can best be recognized under the microscope. Pure bacteriuria—i. e., when, as is not infrequent, no inflammatory lesions exist—can sometimes be recognized by holding the test-tube or graduate containing the urine up against a bright light, as before a window, and shaking it briskly. A peculiar, shimmering, wavy, opalescent brightness in the urine can be seen, as though the fluid contained cholesterin.

The colon bacillus is the most common form giving this appearance. In twenty-five per cent of typhoid fever cases, bacilli are found in the urine after the second week. They may persist after convalescence, and though the feces of such individuals are a more serious menace to the health of others, the urine may also be contagious.

I insert a short schema from Ultzmann, which illustrates in a simple form the way of distinguishing the opacities just mentioned:

WHEN THE OPACITY OF THE URINE UNDER GRADUAL HEATING IN A TEST-TUBE

Disappears—	Becomes denser—			Remains unchanged even if acetic acid is added—
It consists of uric-acid salts (Sed. laterit.).	It consists of either carbonates (Carbonaturia), or of earthy phosphates (Phosphaturia), or of purulent catarrhal secretion (Pyuria). After the addition of 1 to 2 drops of acetic acid,			It consists of increased mucous secretion, of spermatozoa, or of bacteria.
	Disappears with the development of gases.	Disappears without the development of gases.	Remains unchanged.	
	Carbonaturia.	Phosphaturia.	Pyuria.	

The Odor of Urine.—As long as urine remains acid the presence of cystitis or other disease of the bladder does not necessarily impart to it any characteristic odor. In some cases of bacteriuria, however, the urine may have a mousy or musty odor, or an odor approaching putridity, and yet without any inflammatory lesion. Bacillus coli is usually present in these cases in enormous numbers. In cases of gangrenous cystitis and in some ulcerative processes of the bladder, including ulcerating tumors, notably epithelioma, the urine has the odor of putrefaction. When, in cases of chronic cystitis, the urine has undergone ammoniacal fermentation, the characteristic stench of a dirty urinal is present. This odor is due to the decomposition of urea into ammonium carbonate by one of many forms of bacteria—bacterium ureæ, micrococcus ureæ liquefaciens, for example.

Other Causes of Turbidity.—In some instances when urine is turbid and alkaline, but has no marked odor, the following test for the presence of triple phosphates is useful:

To the urine in a test-tube is added a little caustic-potash solution. The urine is heated over a flame. If the steam given off turns red litmus paper blue, ammonio-magnesium phosphate is present. This indicates a chronic and severe infection of the bladder with decomposition of urea. It is more often met with in the cystites of enlarged prostate and of insufficient and paretic bladders than in gonorrheal or tuberculous cystitis. The last form of infection appears to be inimical to alkaline decomposition of urea.

Oxalate of Lime.—The presence of oxalate of lime may be tested as follows: The turbid urine is heated and acetic acid added. The turbidity remains. If the urine clears up on adding hydrochloric acid, the turbidity was due to crystals of oxalate of lime.

Donne's Test for Pus.—If in spite of the several tests described the urine remains turbid, caustic-potash solution is added in considerable quantity

and the mixture shaken. If the turbidity is due to *pus*, the urine will assume a gelatinous consistence and will become clear. An identical change goes on in the interior of the bladder in cases of cystitis with ammoniacal decomposition. The urine becomes thick, and so viscid that it will scarcely flow through a catheter, and contains large gelatinous masses of partly translucent material in which are embedded countless crystals of ammonio-magnesium phosphate and myriads of cocci and bacilli, the latter often motile. The characteristic odor is usually marked. When the test is made in a test-tube or beaker and the amount of pus is large, the urine comes to resemble honey, so that it clings to the sides of the glass and cannot be poured out completely.

Chyluria.—Turbidity due to fat in the urine is cleared up by shaking with ether.

Blood.—Two chemical tests for blood are commonly used: (1) Heller's test and (2) the formation of Teichmann's hemin crystals.

Heller's Test.—A test-tube is filled one third with urine, potassium or sodium-hydrate solution is added, and the mixture heated to boiling. The earthy phosphates are thrown down as basic salts, and carry the blood with them. The test-tube is set aside; after ten minutes the earthy phosphates appear as a blood-red (oxyhemoglobin) or brownish-green (methemoglobin) flocculent precipitate, and after a time form a colored layer at the bottom of the tube. If the patient is taking rhubarb or senna, the precipitate may be colored in a similar manner, but the pigment is more of a reddish-violet color. The urine will, moreover, contain no albumin, or not a quantity which corresponds to the amount of blood. Also, such urines turn red on the addition of an alkali, and bright yellow on adding an acid, such not being the case with bloody urine.

Teichmann's Hemin Crystals.—To produce Teichmann's hemin crystals (Ultzmann's method) the urine is placed in a conical glass and allowed to settle for some hours, or in the centrifuge, until complete precipitation of the sediment has occurred. The supernatant urine is removed and the sediment filtered through a tiny filter. A small portion of the sediment is then removed from the filter with the blade of a penknife, spread upon a microscope slide, and allowed to dry. When quite dry, a small portion of sodium chlorid is placed on the slide near the dried sediment, and reduced to fine powder with the blade of the knife. The finely divided salt is then rubbed with the knife-blade into the sediment, as one would sharpen a knife on a stone. There remain clinging to the sediment some fine particles of salt; the rest may be blown away. Next, a few drops of glacial acetic acid are added; a hair and a cover-glass are placed on top. The slide is then quickly heated over a flame until the acid boils—i. e., until bubbles appear beneath the cover-glass. The slide is then removed from the flame and more acetic acid is added, drop by drop, and allowed to flow under the cover-glass until steam ceases to be given off. When the preparation has cooled, it is placed under the microscope, and if blood was present, even in very small amount, numerous slender, brown

crystals, in the form of rods or of long rhombic plates of *hemin* or hydrochlorid of hematin will be visible (see Fig. 158).[1]

Hematuria may be distinguished from hemoglobinuria by the presence of red cells under the microscope in the former, their absence in the latter.

Hemoglobinuria is observed in poisoning by arsenic, naphthol, glycerin, carbolic acid, sulphuric acid, after intravenous infusions of pure water—i. e., without salt—and in profound jaundice. Also, in a number of infectious diseases—syphilis, smallpox, scarlatina and other exanthemata, and in tropical malaria. A further means of differentiation is, that in hematuria the chemical reactions for blood are less marked in the filtered than in the unfiltered urine; such is not the case in hemoglobinuria. Blood may also be readily detected by the absorption bands seen in the spectroscope when a solution containing blood is interposed.

FIG. 158.—HEMIN CRYSTALS. (After Ultzmann.)

In case the turbidity has failed to disappear after the above-mentioned tests, it is probably due to bacteria, readily recognized under the microscope.

SERUM ALBUMIN.—For the qualitative determination of *serum albumin* it is desirable to filter the urine if turbid, notably the urine of women. If they have a leucorrheal discharge, the contamination will sometimes give a positive test for albumin. The tests in common use are: (1) The boiling test with nitric acid; (2) the boiling test with acetic acid; (3) Heller's cold nitric-acid test; (4) the ferrocyanid-of-potassium and acetic-acid test.

1. The filtered urine is boiled in a test-tube. If a precipitate occurs, it may be phosphates or albumin. Five to ten drops of nitric acid are added. If albumin is present, the cloud remains, or forms a precipitate. Phosphates disappear on adding the acid.

2. After boiling, a few drops of acetic acid are cautiously added. The precipitate remains if albuminous, but is redissolved by an excess of acid.

3. Heller's cold nitric-acid test. This is a coagulation test made with pure concentrated nitric acid (Ultzmann), with twenty-per-cent nitric acid (Blumenthal). A wineglass, with conical sides but not too sharply conical bottom, holding 20 to 30 c.c., is half filled with clear or filtered urine. About half the quantity of acid is then slowly added by pouring it down the side of the glass, the two containing vessels being inclined toward one another meanwhile.

[1] Strzyzowski's modification is more delicate. The reagent is glacial acetic acid, water and alcohol, each 1 c.c. + 3 to 5 drops of hydriodic acid of a specific gravity of 1.5. (Wood. Chemical and Microscopical Diagnosis, page 18. Appleton's New Medical Series.)

The heavier acid falls to the bottom and forms a separate layer beneath the urine. In normal urine there will then be a clear layer of acid at the bottom, a clear layer of urine on top, and between them a thin brown layer caused by the action of the acid on the normal coloring matter of the urine. If albumin is present there will appear above the colored layer a thinner or thicker white layer of coagulated albumin, according to the quantity of albumin in the urine. If an unusual quantity of uric acid or urates is present, the entire layer of urine may become slowly turbid. The urine should then be diluted with an equal quantity of water and the test repeated, when it will usually be successful. If the patient is taking turpentine, or copaiba, or styrax, a similar cloudiness may appear. In order to avoid this the urine may be diluted with double its volume of alcohol.

4. As a qualitative test for albumin, the ferrocyanid-of-potassium and acetic-acid test is exceedingly delicate. The urine, if not clear, is filtered and acidified with acetic acid; one or two drops of a ten-per-cent solution of ferrocyanid of potassium are then added. If albumin is present, a white, cloudy precipitate appears, which grows more marked on shaking. The delicacy of this test is such that albumin may be detected in a dilution of 1 to 50,000.

Prepeptone is also precipitated by this test. Prepeptone is found in the urine in a variety of pyogenic infections; in ulcerative lesions of the alimentary tract; in carcinoma, notably of the alimentary canal; in acute yellow atrophy of the liver; in phosphorous poisoning, and in other conditions.

Esbach's Albuminometer.—The use of the Esbach albuminometer is a simple and convenient method for determining the quantity of albumin. The instrument consists (see Fig. 159) of a thick-walled test-tube. The test is made as follows: The tube is filled with urine up to the mark U, and then with the reagent up to the mark R, and then well shaken. The mixture is allowed to stand until the following day, when the height of the precipitate, read off from the scale on the wall of the tube, indicates the content of albumin in parts per 1,000.

FIG. 159.—ESBACH'S ALBUMINOMETER.

The reagent consists of nitro-picric acid 5.0, citric acid 10.0, water 500.0. Though the method is only approximate and small errors may occur, yet the results are close enough for most purposes.

For the determination of *serum albumin*, quantitatively, in the presence of *pyuria* or *hematuria*, or both, it is desirable to know whether the albumin corresponds to the amount of pus or blood. Pyuria alone rarely produces an albuminuria greater than 1 to 1,000, unless an abscess or a pyonephrosis has recently emptied into the bladder. If with these exceptions the albumin exceeds this amount, nephritis probably coexists, cardiac disease, etc. For differentiation between *propeptone* and *serum albumin*, see special works on the urine.

Sugar.—Sugar in the urine is detected by the well-known reduction test with Fehling's solution, by the fermentation test, or by viewing a column of urine by polarized light.

MICROSCOPIC EXAMINATION OF THE URINE, ESPECIALLY IN DISEASES OF THE BLADDER

The *sediment* is obtained by placing the urine in a centrifuge or by letting it stand for a number of hours in a conical glass.

In pure *bacteriuria* scarcely any sediment is obtainable. If *blood* alone is present, it often collects like a drop of red sealing-wax at the bottom of the tube. *Pus* settles as a heavy, dense, yellowish-white precipitate. A portion of the sediment is spread upon a slide, covered with a cover-glass, and examined under the microscope. We are at once able to distinguish three

Fig. 160.—Uric Acid in Its Most Common Form. (After Ultzmann.)

Fig. 161.—Sodium Urate. (Ultzmann.)

types of material: amorphous material, crystalline material, organized material—i. e., cells, casts, spermatozoa, etc. Urates and earthy phosphates may appear as an amorphous powder, soluble in a drop of hydrochloric acid. Uric acid appears in the form of delicate rhombic plates (see Fig. 160). Sodium urate and calcium phosphate appear as delicate needle-shaped crystals, often arranged in the form of rosettes (see Figs. 161 and 162). Ammonium urate occurs in alkaline urine in the form of little balls with needlelike radiating projections. Cystin occurs in the form of thin, delicate, six-sided plates. Cholesterin forms thin rhombic plates with sharply marked angles. Those crystals showing well-marked development in three dimensions are either uric acid, oxalate of lime, or ammonio-magnesium phosphate. While uric acid may occur in a variety of forms, the most common is that of rhombic plates the obtuse angles of which are round—the whetstone form. Their shape and golden-

color are characteristic (see Fig. 160). Rhombic crystals arranged in are not uncommon. Oxalate-of-lime crystals occur usually in the so-called envelope form. They are tetragonal octahedrons (see Fig. 164). Triple phosphates occur chiefly in the so-called coffin-lid-shaped crystals (see Fig. 165).

Cellular Elements in the Urine.—As has already been stated (see Kid-

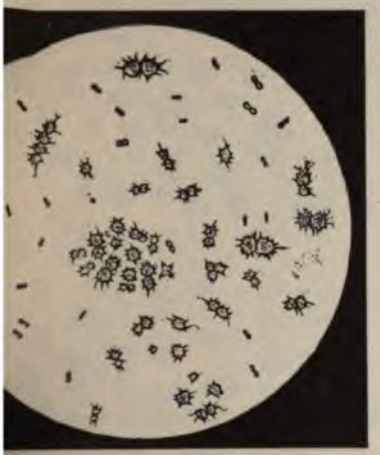


FIG. 162.—AMMONIUM URATE. (After Ultzmann.)

FIG. 163.—CHOLESTERIN CRYSTALS. (After von Jaksch.)

e location of disease in the genito-urinary tract cannot be certainly fixed e form of the desquamated epithelial cells as they appear in the urine. from Posner, who has given much attention to this matter:

nal urine may contain a few delicate, flat epithelial cells. They originate bladder from the constantly occurring maceration of the vesical mucosa.

FIG. 164.—OXALATE OF LIME. (After Ultzmann.)

FIG. 165.—TRIPLE PHOSPHATE. (Ultzmann.)

en there occur in addition, from the vulva and vagina, a certain number , flat epithelial cells. Also, we sometimes find in urine masses of epi-ells bunched together in an unrecognizable form, or so that they resemble of tissue, glandular tubules, for example, sometimes distinctly papillary

growths, in the interior of which a blood-vessel may usually be recognize tablishing the diagnosis of a papilloma. In the presence of tumors of the u

FIG. 166.—CALCIUM PHOSPHATE. (Ultzmann.)

FIG. 167.—PUS CELLS IN URINE. Partly ical, partly with irregular projection the lower third of the field, pus cells with a drop of acetic acid rendering the plasm transparent and the nuclei (Ultzmann.)

passages other particles of tissue are often found. Connective tissue, containing groups of cells, for example. It is rarely possible, however, to distinguish the character of the tumor from structures.

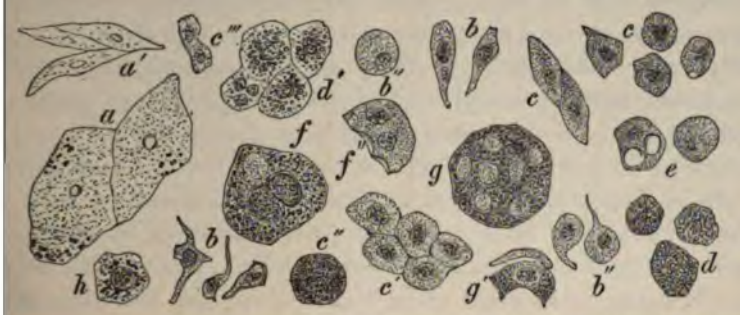
The organic and cellular elements originating in the kidney may, how be recognized with certainty. This includes well-formed cubical epitheliu well as the various forms of casts inating in the kidney tubules—i. e., line, granular, fatty, waxy or epith casts. Their presence indicates that kidney is involved in the disease.

FIG. 168. — BLOOD CORPUSCLES IN URINE. Some of them intact, showing shadows indicating the central saucerlike depression. Some swollen into spheres with no central depression. Some dissolved, appearing as shadowy spots merely. Some crenated (Thorn Apple Forms). All these forms may occur side by side, except the swollen edematous type which occur only in highly diluted urine. (Ultzmann.)

Ultzmann used to lay special s upon the fact, that by the microsc examination of the shreds appea in the urine during chronic gonor one could tell whether the inflam tory process was still active or healing. If the shreds contained cells merely, the healing process not yet commenced. If pus and thelial cells were both found, the l was in the process of healing. W epithelial cells alone appeared, the ing process was complete. I have in the habit of watching the pro

f chronic gonorrhea in this way, and have found these observations able.

the Urine—Pyuria.—We are unfortunately not able by microscopic on of the urine to distinguish the anatomical source of pus. In s the history, the physical examination, the distinctly localized char- ie symptoms, and the concomitant chemical and microscopic findings



PITHELIA FROM THE GENITO-URINARY TRACT. *a*, *a'*. Flat epithelia in urinary sediment. . Epithelia from the bladder. *c*, *c'*, *c''*, *c'''*. Kidney epithelia. *d*, *d'*. Epithelia showing generation. *e–h*. Bladder epithelia. (R. v. Jaksch.)

to exclude one or other portion of the genito-urinary tract. In other cystoscope and ureteral catheterization are sure and necessary diag- ans.

s formerly believed that, as a general rule, pyuria with acid urine fection of the kidney and a renal source for the pus, while alka- ammoniacal urine indicated We now know that the ques- t so simple; cystites of many ay be accompanied by acid s being notably true of tuber- d gonorrhea, the ammoniacal ion observed in certain cases merely upon accidental in- ith certain forms of bacteria 171).

ewhere stated, insufficient blad- residual urine are prone to of cystitis, catheter infection cause. The microscopical *purulent cystitis with acid urine* will be as follows: In d there will be seen numerous ls, often in masses, some of nal in shape, some of them showing ameboid processes; in addition, ithelia in small or moderate number. Blood may be present or absent

FIG. 170. — URINARY SEDIMENT IN ACUTE CYSTITIS. Blood and pus cells, spherical ammonium urate. Triple phosphate. Bladder epithelium. Amorphous earthy phosphates. (Ultzmann.)

(see Figs. 167, 168, 169, of pus cells in urine, of epithelia from various parts of the genito-urinary tract, and Figs. 170, 171, 172, of urinary sediment in acute, chronic, and putrid cystitis). The epithelia may be round, cylindrical, or tailed. If the urine is alkaline, we find, also, thorn-apple crystals of ammonium urate, triple phosphates, and calcium carbonate. Bacteria of various shapes are often numerous and motile. If gonorrhea is the cause, the dried and stained specimen will sometimes show the characteristic biscuit-shaped cocci in pairs and fours, grouped about the cell nuclei or filling the cell protoplasm almost completely. The nuclei of the pus cells are multiple, usually two or three in each cell, and are deeply stained. In other forms of cystitis, in addition to bacillus coli and numerous saprophytic forms, the ordinary pyogenic cocci, staphylococci, and streptococci are found. In very mild forms of irritation of the bladder, the result of alcoholic or sexual excess, with symptoms of frequency merely and little or no pain, the amount of mucus in the urine may be increased, and the number of bladder cells. The number of *leucocytes* in a field will never be as great as in *true cystitis*, nor will they occur, as in cystitis, in dense masses and clumps.

In cystitis with *ammoniacal fermentation*, the pus cells are swollen and the protoplasm clear, showing the nuclei; in addition, swarming millions of bacteria. The urine of *putrid and gangrenous cystitis* shows under the microscope few distinguishable tissue elements. The sediment is abundant, and has a brown or greenish color, sometimes almost black. The foul odor is partly due to the presence of ammonium sulphid. Microscopically there are myriads of bacteria, granular detritus, and triple phosphate crystals. Few or no cells can be identified. Such urine is found in the end stages of enlarged prostate, in the presence of malignant growths in the bladder, in gangrene of the bladder, and in diphtheria of the bladder. The urine is alkaline and the specific gravity is low.

THE ABSORPTION TEST FOR RAW AND ULCERATED SURFACES IN THE BLADDER

In certain cases of hematuria a vesical source may sometimes be demonstrated by what is known as the *absorption test*. The intact and healthy vesical mucosa absorbs but little of the materials held in solution by the urine. In cases of retention of urine, so long as the epithelial lining of the bladder is intact the patients do not become uremic. If, on the other hand, abraded or ulcerated surfaces exist, such patients may develop uremic symptoms quite rapidly. The latter condition is often observed in cases of cancer of the bladder complicated by retention of urine.

The *absorbing power*, and therefore the presence or absence of *raw surfaces*, in the bladder may be tested in the following way: A soft catheter is introduced into the bladder, and the interior is gently washed repeatedly with salt solution until the water returns clear. Two or three ounces of a one-per-cent

on of iodid of potassium is then injected into the bladder with a hand ge, and the catheter is withdrawn. After waiting fifteen minutes, the nt is requested to collect some of his saliva in a test-tube or any small vessel. To the saliva is added a few drops of a dilute solution of cooked h. The mixture is then stirred with a glass rod which has been dipped ning nitric acid. If the liquid turns blue, iodin is present in the saliva. *itive* reaction indicates that iodid of potassium has been absorbed from the er and is being eliminated by the salivary glands, and is proof positive raw or bleeding surface exists in the bladder, and in cases of hematuria ates the bladder as the source of blood. In the healthy bladder no positive on for iodin in the saliva will be obtained, even after the lapse of an (Ultzmann).

CHAPTER XXVI

CYSTITIS

(*Inflammation of the Bladder*)

Etiology.—For the production of cystitis, it is usually assumed that two factors are necessary: a predisposing cause, and the presence of one or other of the forms of pathogenic bacteria capable of infecting the vesical mucous membrane or of causing ammoniacal decomposition of urea, or both. It is certain that in many cases of cystitis several bacterial forms are associated. It is to be borne in mind that the mere introduction of bacteria into the healthy bladder does not produce cystitis. A transient bacteriuria alone results. Cases of chronic bacteriuria (usually colon bacillus) without inflammatory complications are not rare. Such may last indefinitely, and if the germs also inhabit the renal pelvis and ureter, may be nearly incurable. The only signs are cloudy urine filled with bacteria, and a musty or stinking odor of the same. Among the *predisposing causes* of cystitis may be mentioned obstructive lesions of the lower urinary tract, stricture of the urethra, prostatic hypertrophy, paralysis of the detrusor of the bladder; any condition, in fact, causing stagnation of urine in the bladder. Further, conditions producing congestion of the lower genito-urinary tract, such as drugs with a selective action upon the urinary organs—cantharides, turpentine, sandal oil, etc.; pelvic tumors; the pregnant uterus; inflammatory exudates compressing the bladder; trauma; tumors of the bladder; stone or other foreign body; infectious processes of other portions of the genito-urinary apparatus, or of neighboring structures. Among the former, *tuberculosis* of the kidney and *gonorrhea* of the urethra are frequent and important. Infectious processes in the vicinity, infecting the bladder by continuity of structure; for example, an appendical abscess which ruptures into the bladder. Cystitis may occur as a rather rare complication in the course of infectious diseases—typhoid fever, the exanthemata, apparently as the result of the elimination of bacteria through the kidney, the living bacteria in the urine causing infection of the bladder.

Among men, two causes exist far more frequent than all others. They are, in youth and adult life, *gonorrhea and stricture of the urethra*; in old age, *enlargement of the prostate gland*. Among women, cystitis is exceedingly common. The causes are to be sought in the frequent occurrence of tumors of the uterus and the adnexa, producing congestion of the bladder by pressure; further, inflammatory pelvic conditions of all sorts, and gonorrhea. Owing to the

ethra, the entrance of infecting organisms into the bladder is easy. Ob- lesions are, however, far less common than among men, and consequent- gh cystitis is frequent among it is far less difficult to cure.

Bacteria of Cystitis.—The bac- ncerned in the production of are of varied character. They operly be divided into two (1) Those which cause am- l decomposition of urea, and e which have a specific inflam- ction on the mucous membrane. h time and effort has been ex- n the study of the bacteriology of Upon certain points the views ent observers are not in accord. facts are, however, well estab- The gonococcus, alone, may be e of gonorrheal cystitis, though infection may occur. The lesion ed for the most part to the pros- thra and the trigone. In some cases the entire bladder may be involved. n bacillus may dwell in the bladder and cause no cystitis. In other cases it will produce a cystitis with acid urine. The tubercle bacillus causes cystitis; often the infection is mixed. The orifices of the ureters and the trigone are the areas first affected in most of the cases. (See Renal Tuberculosis.) Numerous bacterial forms cause decomposition of urea, with the production of rather sharp crystals of triple phosphate and the formation of ammonium carbonate. Cystitis of a peculiarly distressing type accompanies ammoniacal urine. Whether the free ammonium carbonate and the crystals act merely as l irritants to the bladder or whether, in addition, the special bacteria specific effect upon the bladder wall, or whether or not the infection s a mixed one, is, I believe, not definitely known.

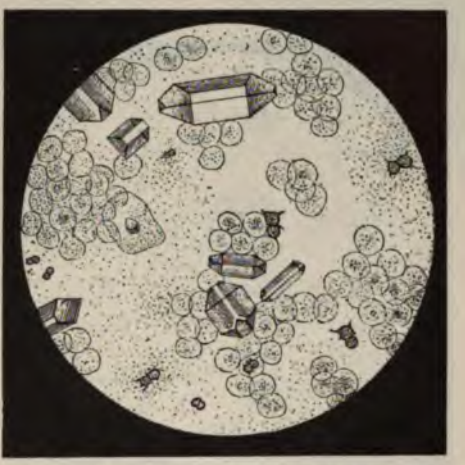
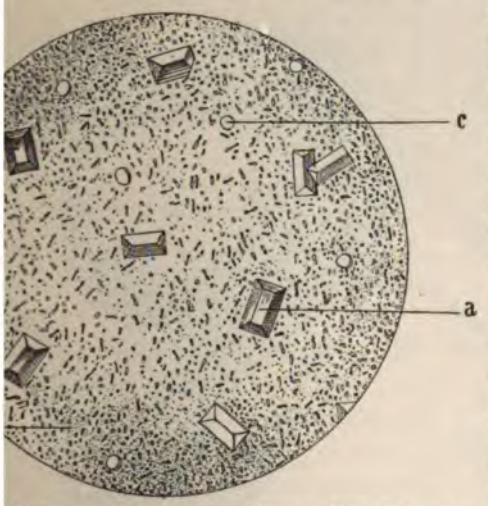


FIG. 171.—URINARY SEDIMENT IN CHRONIC CYSTITIS WITH AMMONIACAL FERMENTATION. Pus cells swollen by ammonium carbonate. A few swollen bladder epithelial cells. Triple phosphate. Ammonium urate. Amorphous earthy phosphates. (Ultzmann.)



—URINARY SEDIMENT IN PUTRID CYSTITIS. *a*. hosphates. *b*. Bacteria and molecular detritus. d corpuscles. (Ultzmann.)

Under special conditions the ordinary pyogenic cocci and the Streptococcus erysipelatis may cause severe forms of cystitis, the former with actual suppuration or necrosis of the bladder wall. In these cases the saprophytes may add a gangrenous or putrid character to the inflammation. Some of the forms causing ammoniacal decomposition of urea are Bacterium ureæ (v. Jaksch), Micrococcus ureæ liquefaciens (Flügge), Urobacillus liquefaciens septicus (Krogius).

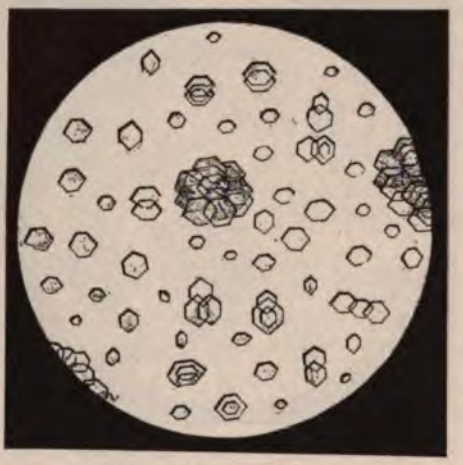


Fig. 173.—Cystin. (Ultzmann.)

Other bacteria associated with some forms of cystitis are: Bacillus pyocyaneus, Bacillus typhosus, certain forms of gas-producing bacteria (Heyse), (Cystitis emphysematosa), the pneumococcus.

Pathological Anatomy of Cystitis.—Cystitis usually begins in the trigone, and may be confined to it and the prostatic urethra or spread over the entire mucous membrane of the bladder, constituting a partial or total cystitis, respectively. The phenomena are injection, swelling, and congestion of the mucosa, with subsequent desquamation of epithelia and exudation of white cells. Ecchymotic areas are developed here and there, and in some cases superficial erosions of the mucous membrane. The urine becomes purulent and contains many epithelial cells and bacteria. Its reaction remains acid or becomes alkaline, according to the character of the infection. If cystitis becomes chronic the mucous membrane is thickened, the veins of the mucosa are dilated, the submucous tissue is infiltrated with round cells. In severe cases the muscular coat is also involved.

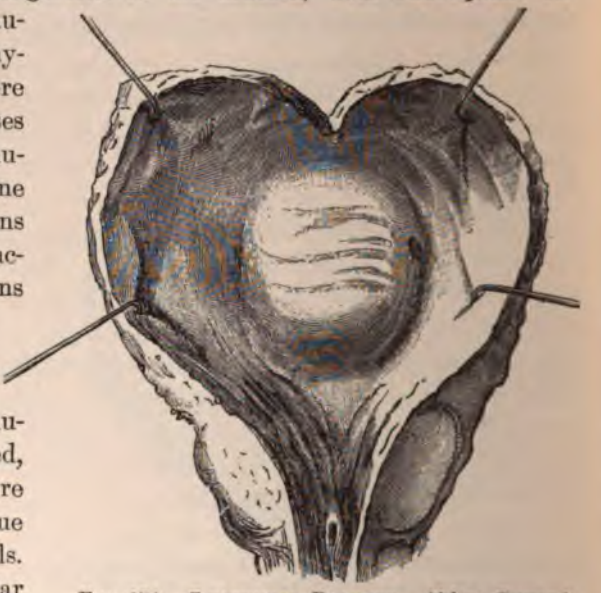


Fig. 174.—Cicatricial Bladder. (After Guyon.)

Parenchymatous Cystitis.—The color of the mucous membrane changes from bright red to dirty grayish-red. The surface of the mucous membrane is coated with adherent flakes of pus. In severe cases minute abscesses may

form in the bladder wall, or larger abscesses may form, perforate the bladder, and produce a *pericystitis*, or the process may end short of suppuration and produce adhesions of the bladder to surrounding structures. In other cases the end result is cicatricial contraction of the bladder (*contracted bladder, atrophied bladder, Schrumpf Blase of the Germans, chronic interstitial cystitis*).

Severe infections may produce gangrene and necrosis of the bladder wall. In such cases the urine is foul with gangrenous shreds of mucous membrane, pus, blood, and detritus.

Membranous Cystitis (*Croupous Cystitis*).—A membranous cystitis, with the evacuation of bladder casts, has been observed, as well as true diphtheria of the bladder. Isolated ulcers of the bladder, nontuberculous in character, have been observed associated with cystitis.

When obstructive lesions complicate cystitis, the muscular wall of the bladder undergoes hypertrophy; the muscular ridges stand out prominently with deep sulci between them, constituting the *trabeculated bladder*. Such bladders may be larger than normal—i. e., dilated—*eccentric hypertrophy*, and are often insufficient, or smaller than normal—*concentric hypertrophy*. In either case the mucosa may bulge through a thinner portion of the muscular wall, and form a sort of hernia, or pocket, sometimes of large size, communicating with the remainder of the bladder by a larger or smaller opening, constituting a *diverticulum* of the bladder.

FIG. 175.—CONCENTRIC HYPERTROPHY OF THE BLADDER. (After Guyon.)

Interstitial Cystitis.—In cases of interstitial cystitis, usually due to gonorrhea, the inflammatory process runs its course, and after a long period may result in atrophy of the bladder wall. The ridges and sulci disappear, the mucous membrane again becomes smooth, the wall of the bladder scarcely thicker than normal; but the bladder has ceased to be an elastic, muscular, contractile organ. It is converted into a mere leathery sack of dense connective tissue, and can no longer, by any means, be dilated to a normal degree. These bladders may hold only an ounce or two of urine. The possessor of such an atrophied bladder suffers much discomfort. The bladder can usually be emptied, or nearly so, by the patient. The residual urine rarely amounts to more than a drachm or two.

Hypertrophy of the Bladder.—Hypertrophy of the bladder of both the dilated and contracted forms is usually seen in old men as the result of pros-

tatic obstruction, less frequently in young manhood and middle age as the result of chronic gonorrhea and stricture. Chronic gonorrhea of the bladder produces more often, when of a severe type, the cicatricial bladder without hypertrophy of the muscular coat.

Eccentric hypertrophy is associated with insufficiency. The amount of residual urine is large. In thin persons the enlarged and thickened bladder is palpable, even when empty, by combined rectal and abdominal touch. A searcher introduced after voluntary urination reveals a considerable cavity, with marked ridges projecting from its walls.

FIG. 176.—ECCENTRIC HYPERTROPHY OF THE BLADDER. (After Guyon.)

In *concentric hypertrophy* the capacity of the bladder is small. Attempts to inject a large quantity of fluid into the bladder are futile. The water runs out alongside the catheter. The walls of the bladder are hard and ridged. The quantity of residual urine is trifling.

Atrophied Bladders.—Atrophied bladders, the result of interstitial cystitis, are small. They cannot be dilated. Their walls are smooth, hard, and inelastic. There is little or no residual urine. These patients may be obliged to urinate every few minutes; many of them are obliged to wear a urinal. They sometimes have nocturnal incontinence. In some cases pyuria is marked, in others very slight. Attempts to increase the capacity of these bladders by forced injections are rarely successful. During the injections the patients suffer much pain.

Pericystitis.—Inflammation of the subserous connective tissue may be secondary to parenchymatous cystitis with the formation of small abscesses in the bladder wall. It is apt to occur around inflamed diverticula. It may be due to trauma—i. e., to wounds of the bladder wall produced by the blades of a lithotrite—and to other extraperitoneal wounds or ruptures of the bladder. In some cases it is due to inflammations of the surrounding viscera—the prostate, the uterus and adnexa, and the appendix. If suppuration occurs, infiltra-

tion of urine and fatal sepsis of purulent peritonitis may result. In some cases an abscess forms, which ruptures into the bladder, the rectum, the vagina, or appears in the perineum. The signs and symptoms of pericystitis are more or less marked *sepsis*. Retention of urine is common. Locally, a tender, painful mass will be palpable, either in the middle line above the pubes or to one side of the bladder. If the bladder is emptied by catheter the tumor remains. There is continuous pain in the region of the bladder, with dysuria or retention. If the process started outside the bladder, the urine may be clear. If secondary to cystitis, there will be pyuria. The formation of an abscess is attended by increased septic symptoms. If the abscess approaches the skin of the abdomen or perineum, localized swelling, edema, redness and brawny induration will develop or, later, fluctuation. Rupture into the rectum is followed by the discharge of pus from the bowel. Rupture into the bladder is indicated by the sudden evacuation of much pus with the urine. Such pus often has a fecal odor. Actual communication between the bladder and the bowel is shown by the discharge of feces or gas, or both, with the urine. The former indicates a large opening; the latter alone a small one.

Suppurative pericystitis is a very dangerous disease. A large proportion of these cases are fatal.

The Symptoms and Diagnosis of Cystitis.—The *cardinal symptoms* of cystitis, of whatever origin, are three: frequent urination, pain, and pyuria. Cystitis

FIG. 177.—EPITHELIA FROM THE FEMALE URETHRA ABOVE, FROM THE VAGINA BELOW.

FIG. 178.—EPITHELIA FROM THE MALE URETHRA ABOVE, FROM LITTRE'S GLAND BELOW.

may be either acute or chronic. The latter form often follows the first, and during a chronic cystitis acute exacerbations are frequent. Severe constitutional symptoms are not commonly present, even in the acute form, unless the inflammation be of a septic or gangrenous type. Gonorrheal cystitis is occasionally ushered in by chilly sensations and a moderate rise of temperature. (See, however, Urethral Chill and Fever.)

Acute cystitis is accompanied by a more or less constant desire to pass water, and the act, when accomplished, is attended by pain. In severe cases the patient must urinate every few minutes. The pain is of a spasmodic character, and is felt before and during urination, but is most severe at the end of the act, when the vesical sphincters close on the inflamed mucous membrane of the trigonum and prostate. The pain is referred to the glans penis, to the perineum, prostate, and rectum. In gonorrheal cystitis, the *prostatic urethra and trigonum being chiefly involved*, the passage of the last few drops of urine is attended by an acute spasm of pain, and these drops are often bloody.

Between the acts of urination a dull, heavy pain is felt in the *sacral region*. When the cystitis is *general*, pain is also felt in the *suprapubic* region, and the bladder is tender on palpation. In some cases of acute cystitis severe spasm of the sphincters leads to complete or partial *retention* of urine. The patient may be able to urinate a little from time to time with painful effort, but he cannot empty his bladder, since no sooner does the stream of urine start than it is checked by the painful, spasmodic contraction of the sphincters. In some of these cases catheterization is difficult, and may require the use of morphin and hot baths, or of cocain anesthesia. In less severe cases of acute cystitis the patient may urinate every hour or half hour. The pain, though similar in character, is not so intense. In *chronic* cases the symptoms of pain and frequency will vary within wide limits. (See Cystitis due to Special C[illegible])

Pyuria is the third essential symptom of cystitis. It is always p[illegible] although at the beginning of an acute attack the amount of pus in the [illegible] is small. If we exclude the cases of cystitis accompanying injuries and diseases of the spinal cord with paralysis of motion and sensation, in which naturally there is neither pain nor desire to urinate, we shall find in every case of cystitis the three cardinal symptoms: frequency, pain, and pyuria. The diagnosis of the anatomical origin of pus in the urine is discussed elsewhere. (See Gonorrhea, Thompson's Test, True and False Albuminuria, Cystoscope, Ureteral Catheterization.)

CHAPTER XXVII

THE NEUROSES OF THE BLADDER

(*Functional Disturbances of the Bladder Due to Nervous Causes*)

Among these conditions are included: (1) Cystospasm, or urina spastica; (2) spasm of the vesical sphincters; (3) paresis and paralysis of the detrusor, insufficient bladder; (4) paralysis and paresis of the vesical sphincters; (5) incontinence of urine, enuresis.

The motor disturbances of the bladder are often combined with sensory disturbances; thus, with cystospasm we often find hyperesthesia of the bladder, and motor paralyses are often combined with loss of sensibility. These disturbances of the bladder are in part due to central causes—i. e., injuries and dis-

Fig. 179.—Epithelia from the Prostate.

Fig. 180.—Epithelia from the Bladder.

eases of the spinal cord and cerebrum, and in part to local lesions of the penis, urethra, prostate, kidney, or the bladder itself.

Cystospasm—Urina Spastica—Bladder Cramp—Irritable Bladder.—In this condition the individual suffers from an uncontrollable frequency of urination, solely during his waking hours and not accompanied by pain. The quantity of urine may be normal or increased. The reaction is often neutral or feebly acid. Phosphaturia, oxaluria, and indicanuria are frequently present. The condition is observed in hysterical and neurasthenic individuals and among

cases. An injection of thirty minims of a four-per-cent cocain solution into the meatus, rubbed backward toward the deep urethra, and left for five minutes, is useful. The sound or catheter should be introduced continuously but very slowly; when its tip reaches the junction of the bulbous with the membranous urethra, gentle direct pressure with the forefinger on the perineum will often succeed in overcoming the spasm. The surgeon feels the instrument slip by the obstruction, and upon sinking the shaft it slips readily into the bladder. These cases are often diagnosticated by the inexperienced as tight strictures of the

FIG. 185.—WAXY CASTS. Amyloid degeneration of the kidney. (Ultzmann.)

FIG. 186.—EPITHELIAL CASTS. Desquamative nephritis. (After Ultzmann.)

membranous urethra. I have seen such cases prepared for operation. Under ether a full-sized instrument slipped easily into the bladder. The treatment consists in the introduction of full-sized sounds three times a week. The sound should be left in the bladder five minutes or more. Cauterizations are also useful.

True cicatricial contraction of the prostatic urethra, the result of chronic gonorrhea, is regarded by some surgeons as an important lesion, often confounded in elderly men with prostatic enlargement. Keyes considers that the three characteristic phenomena are: (1) chronic unconquerable posterior urethritis; (2) imperative urination; (3) dysuria. The treatment of this condition is perineal section and the introduction of the forefinger through the prostatic urethra into the bladder.

Paretic and Paralytic Conditions of the Detrusor Muscle and of the Vesical Sphincter.—Inability to completely empty the bladder in the absence of any organic obstruction is known as *paresis* of the bladder. Total inability is *paralysis*. They depend upon partial or total loss of contractility in the detrusor muscle. Such impairment may be due to defective innervation or to degenerative changes in the muscle itself. Paresis or partial impairment is seen in diseases of the spinal cord, in acute febrile diseases in which cerebration is

and the condition often occurs in the preataxic stage. (See also Paresis of the Bladder.) The therapy of irritable bladder consists of general tonics and bromid of potassium internally. Locally, the passage of large sounds every two days; and this failing, astringent irrigations or cauterizations of the prostatic urethra.

Spasm of the Vesical Sphincter.—These patients complain not of frequent urination, but of difficulty in starting the stream. They may have to strain

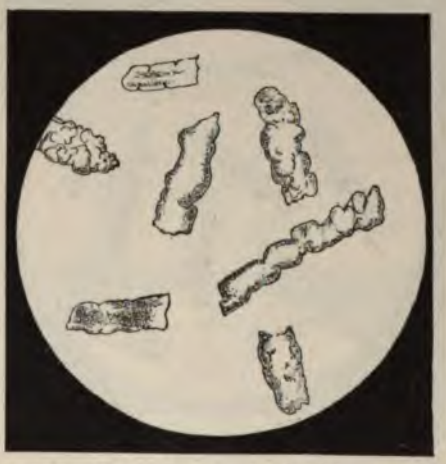
FIG. 183.—HYALINE CASTS. (After Ultzmann.)

FIG. 184.—FINELY GRANULAR CASTS. Advanced chronic diffuse nephritis. (Ultzmann.)

for several minutes, and when finally urination is started the stream is small and without force. As they proceed the stream becomes larger, of normal size, but again diminishes, and when they think they have finished and button their trousers they find that some urine still escapes and wets them or their garments.

The cause of this condition lies in hyperemia, congestion or catarrh of the prostatic urethra, and is dependent upon an imperfectly cured posterior urethritis more often than anything else. A contracted meatus urinarius, masturbation, excessive coitus, and prolonged ungratified sexual excitement may be responsible in certain cases. These patients are also extremely sensitive to the passage of a sound, and its introduction, however gentle, is often followed upon withdrawal by a few drops of blood. In some of these cases the symptoms are really severe, the patients may suffer from retention of urine, and catheterization may be difficult. When the point of the instrument touches the external sphincter (compressor urethræ muscle) a spasm is excited which prevents its further passage. The condition is a true *spasmodic stricture*. Should the surgeon now exert strong pressure or move the beak of the instrument about in order to find the opening, the spasm will be increased. Extreme gentleness and patience will alone overcome the difficulty. A large, rather than a small, instrument should be chosen. A large, blunt, metal sound or catheter is far safer than a small one, and soft instruments will not, as a rule, pass in these

cases. An injection of thirty minims of a four-per-cent cocain solution into the meatus, rubbed backward toward the deep urethra, and left for five minutes, is useful. The sound or catheter should be introduced continuously but very slowly; when its tip reaches the junction of the bulbous with the membranous urethra, gentle direct pressure with the forefinger on the perineum will often succeed in overcoming the spasm. The surgeon feels the instrument slip by the obstruction, and upon sinking the shaft it slips readily into the bladder. These cases are often diagnosticated by the inexperienced as tight strictures of the



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dull, and as the result of overdistention of the bladder. The last two are usually temporary conditions, though a single great distention may be followed in some cases by permanent atony.

In old age, even in the absence of prostatic hypertrophy, partial paralysis of the detrusor is by no means rare, due to senile degeneration of the muscular wall of the bladder. The paresis is often combined with loss of power in the vesical sphincter, and is sometimes accompanied by senile atrophy of the prostate. In diseases of the spinal cord the paresis may be due to tabes or to combined sclerosis—i. e., a diffuse sclerotic degeneration of the posterior and lateral columns of the cord, resulting in a combination of symptoms, in part those of locomotor ataxia, in part those of spastic paraplegia, sometimes to the pressure of a tumor of the cord. In addition to motor paresis, disturbances of sensation, either hyperesthesia or diminished sensation may be observed. The latter may be combined with abnormal sensations, pain, a sensation of distention of the bladder, etc. Thus in tabes the patients may have a diminished sensibility of the bladder so that they do not know when it is distended, or they may feel that the bladder is full when it is not. Often they suffer from the symptoms resembling those of spasms of the vesical sphincter, so that they have difficulty in starting the stream. They must strain or press upon the abdominal wall or assume some unusual attitude before they can urinate. In addition there is often an actual loss of power in the detrusors, so that these patients gradually develop insufficient bladders. This may be combined, as I have seen in a number of cases, with paresis of the sphincter, so that after the bladder contains a certain amount of urine, they begin to dribble, and are forced to wear a urinal. These patients are not in my experience much benefited by local treatment. They rarely need to be catheterized, and if this is done they are very apt to develop a cystitis, which readily becomes ammoniacal.

The cases of acute febrile disease associated with paresis of the bladder should be regularly catheterized with exceeding care as regards asepsis. As convalescence is established the power of the bladder returns.

In old age paresis of the bladder may be treated by catheterization attended by all due precautions; if allowed to catheterize themselves, old men can rarely be made to take proper care in regard to asepsis. Retention with great distention in old men should be treated by gradual evacuation of the bladder at several sittings, or by emptying the bladder at once and replacing the urine by 100 to 150 c.c. of boric-acid solution.

If the greatly distended bladder is completely emptied at once, the subsequent history may be varied. The patient may at once develop a severe hemorrhagic cystitis, with chills, fever, prostration. If the kidneys are bad, sudden or gradual suppression of urine, uremia, and death may follow. In other cases the cystitis will come on gradually, but will end by being severe, with ammoniacal urine, ascending infection, and pyelonephritis. As elsewhere stated, the ureters are often dilated in such cases, so that ascending infection is easy. In other cases, notably in those who already have a severe cystitis, retention

of urine, great distention of the bladder, and sudden evacuation of its contents is followed by acute and fatal septicemia.

In distinguishing between paresis of the detrusors alone and paresis of the vesical sphincters, the following data may be used: In paresis of the detrusors, if the individual is thin the bladder may be palpable as a rather flabby, but distinctly elastic, fluctuating tumor above the pubes. So long as the sphincter remains intact these patients do not dribble until the bladder is greatly distended. The catheter will evacuate from 200 to 1,000 c.c. or more, even when the patient has urinated voluntarily. In paresis of the vesical sphincter, on the other hand, no such amount of urine will be found in the bladder. These patients will begin to dribble long before the bladder is much distended. Such dribbling will be noticed during the daytime when the patient is up and about; at night, when he is recumbent, the action of gravity is not so favorable for leakage. When catheterizing these patients, the following may be observed: If the sphincter is intact some slight resistance will be met with at the bulbomembranous junction. If the sphincter is paretic the instrument slips into the bladder without the slightest resistance. If the detrusor is paretic and the patient be catheterized in the recumbent posture, the urine will begin to flow in a full stream. Long before the bladder is empty the stream will grow weaker and finally stop. Pressure above the pubes will cause the urine to flow again, and, if now the patient assumes the upright posture, quite a quantity of urine will still escape through the catheter by the action of gravity (Ultzmann).

Injuries of the spinal cord are commonly attended by disturbances of urination. Retention of urine occurs from loss of power in the detrusor muscle of the bladder. Incontinence does not result from injuries of the cord, as a primary condition. There is usually developed, after a time, incontinence from overflow; either a constant dribbling or the discharge of small quantities of urine at frequent intervals. Usually, though not always, the patient is unconscious of his distended bladder. In some cases, soon after the injury, incontinence will occur when the bladder becomes greatly distended; in others, the tone of the sphincter is such that the bladder would burst if the urine were not drawn off. The center for the detrusor is in the lower sacral segments of the cord. The nervous mechanism for the sphincter is not definitely understood.

Enuresis—Incontinence of Urine in Children.—Up to the second year of life infants evacuate the bladder when it is full, irrespective of time and place. The act is involuntary and beyond control. After that period they gradually learn to urinate only on suitable occasions. When they do not acquire this habit and wet the bed at night, or their clothing in the daytime during violent exercise, coughing, laughing, etc., they are said to suffer from nocturnal or diurnal incontinence of urine, or, if the incontinence is constant, from continual incontinence. This incontinence is usually observed between the ages of ten and three years, and in the absence of some organic lesion is very rare after puberty. The causes, in the absence of any local lesion, are rather obscure. Several

ories have been advanced to explain the phenomena, none of them quite isfactory. The incontinence usually occurs during sleep. In order to avoid iagnostic errors, these children should be examined locally and generally with care. Among the nervous diseases which may be attended with incontinence is chorea. In this disease the incontinence is spasmodic, and may occur at any hour; other symptoms of chorea will be present. Diabetes should be thought of. I have observed the condition in children with defective mental development due to original defects in the cerebrum, and in cases of retarded development due to pharyngeal adenoids and enlarged tonsils. In the latter condition, removal of the tonsils and adenoids has cured the incontinence. Among local causes affecting both sexes are cystitis, vesical calculus, fissure of the anus, gonorrhea of the urethra and rectum, and oxyuris vermicularis in the rectum. In boys a long and adherent or narrow prepuce, a very small meatus urinarius. In girls an adherent preputium clitoridis, inflammation of the vestibule, polypoid growths (urethral caruncle), a narrow and irritable urethra. I have cured a number of cases in girls by repeated dilatation of the urethra with steel sounds. In children otherwise healthy the trouble usually disappears before puberty.

CHAPTER XXVIII

VESICAL CALCULUS

(*Stone in the Bladder*)

Vesical calculi may originate in the kidney or in the bladder. In the former case they pass as small stones through the ureter to the bladder and become the nuclei of bladder stones. In these cases the history of attacks of renal colic, of hematuria, or of the passage of urinary sand or gravel may aid in the diagnosis. Chemically, bladder stones resemble for the most part those found in the kidney. They consist of (1) uric acid and its salts, (2) oxalates, (3) phosphates, (4) rarely of cystin or indigo.

(1) Calculi of pure uric acid are rather rare. They are most frequent during advanced age. In childhood calculi of uric-acid salts are common. Many calculi consist of mixed urates combined with uric acid. (2) Calculi of pure oxalates are rare, although oxalate of lime forms one of the ingredients of many calculi. Usually oxalate stones have a nucleus of uric acid or urates. (3) Phosphatic calculi consist either of earthy phosphates, or more commonly they contain a nucleus of uric acid, or in rare cases of oxalate of lime. Phosphatic calculi originating in the kidney are usually very hard, and consist of phosphate of lime and of crystalline magnesium phosphate. If, on the other hand, they have formed in the bladder in the presence of ammoniacal fermentation, they are very soft and consist of triple phosphate with a small amount of ammonium urate (Ultzmann). (4) Cystin calculi consist of pure crystalline cystin, rarely mixed with a small amount of other ingredients. Among the rare forms of calculi may be mentioned indigo, carbonate of lime, cholesterin, and xanthin.

As is the case with renal calculi, bladder stones rarely consist of any one material. Commonly the stone is composed of successive layers of several ingredients, or of layers some of which consist of several ingredients, others of but one. According to Ultzmann, the most common combinations are the following: (1) The nucleus of uric acid or urates, the outer layers of oxalate of lime; (2) the nucleus of uric acid or urates, the outer layers of earthy phosphates; (3) the nucleus of uric acid or urates, a second layer of oxalate of lime, the outer layers of earthy phosphates.

Vesical Calculi, Single or Multiple.—The solitary calculi, when they develop free in the bladder, were believed by Ultzmann to assume definite shapes, according to the crystalline system to which the materials forming the calculi

belonged. Thus, he believed that calculi of urates, cystin, and phosphates always had the shape of a flattened ovoid, and that oxalate calculi were always irregularly flattened spheres. The former group belonging to the rhombic

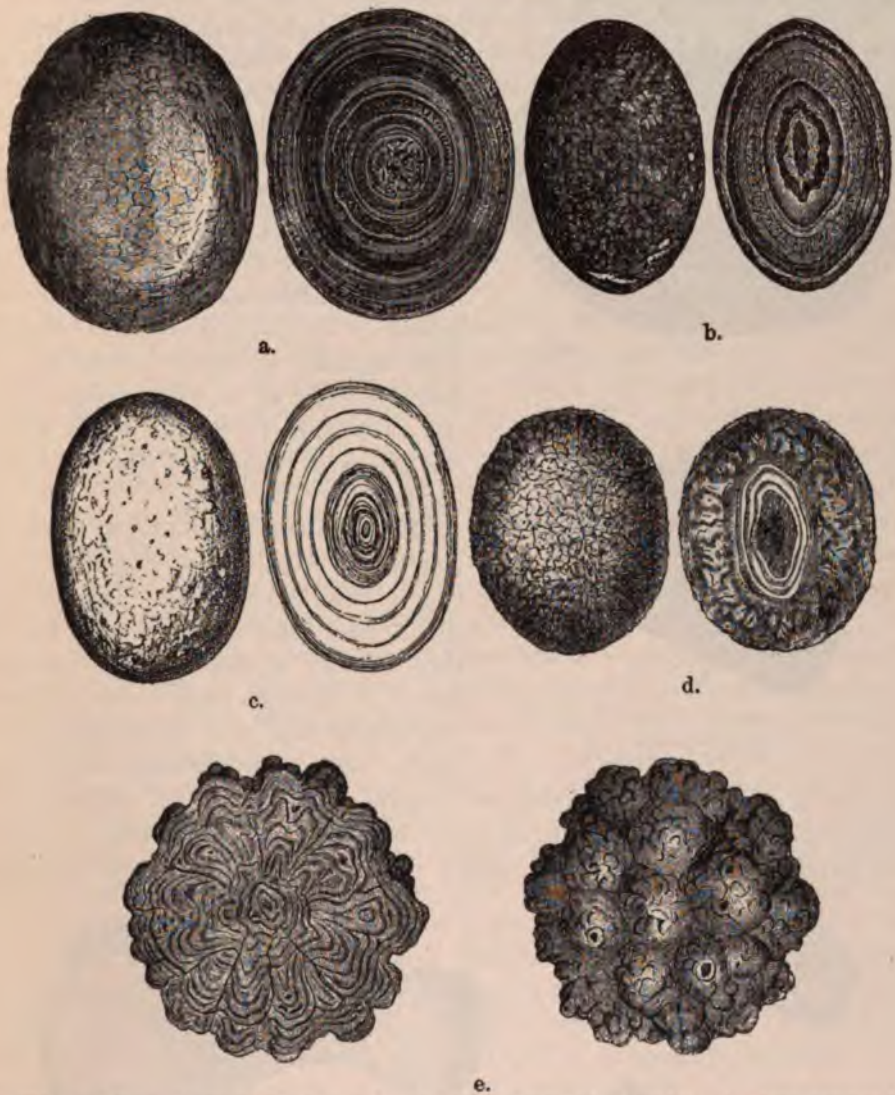


FIG. 187.—*a*. Stone of crystalline uric acid. *b*. Stone composed of urates. *c*. Stone composed of earthy phosphates. *d*. Stone composed of cystin. *e*. Stone composed of oxalate of lime. (After Ultzmann.)

system of crystallization had three diameters. The oxalates belonging to the quadratic system had but two diameters.

The conclusions of Ultzmann in regard to the shape of bladder stones are not in accord with the views of more recent observers—Rainey, Harting, Ord, Ebstein, and others. His researches led Rainey to believe that stone formation

is not a simple deposition of salts present in excess in the urine. He believed that the shape of bladder stones depends upon the law of molecular coalescence —i. e., "in the presence of colloid or albuminoid substances, crystalline materials become spheroidal in shape and coalesce in rounded form." The albuminoid material may be furnished by the irritation caused by crystals in the urine, or any foreign body, or may be ready at hand in the presence of cystitis, a blood clot, bacterial colonies, etc. Once this crystalloid deposition is started the stone itself, by irritation of the bladder wall, continues to cause an exudation of albuminous material and the deposition of successive layers of salts. This appears to be the generally accepted theory of the formation of calculi, although, so far as I am aware, the theory of Ultzmann has never been disproved.

FIG. 188.—FACETED VESICAL CALCULI. (After Ultzmann.)

When calculi are multiple, or though single are fixed, they depart in shape widely from these types. If numerous small free calculi are in the bladder they assume a more or less spherical form. If several large stones are present, so large that they can no longer move freely, they often become faceted (see Fig. 188). If a stone is partly or entirely contained in a diverticulum, it assumes the shape of that cavity and may be quite irregular in form. A stone fixed partly in the urethra and partly in the bladder may assume a shape

FIG. 189.—TOBACCO-PIPE CALCULUS AND CALCULI FROM DIVERTICULA OF THE BLADDER. (After Ultzmann.)

resembling the bowl of a Turkish tobacco pipe (see Fig. 189). If the nucleu of the stone is a foreign body, the stone forming upon it will resemble the for eign body in shape. Stones which become so large that they fill the entir

bladder have a shape more or less closely resembling a cast of the distended bladder.

The Color of Vesical Calculi.—The color of vesical calculi is varied, depending upon a number of conditions. Uric-acid stones are dull yellow, reddish-brown, or reddish-yellow. Oxalate stones are usually black or brownish or grayish-black. Phosphatic stones are white or grayish-white. If they have long been exposed to blood pigment they may be black. The *consistence* of pure uric-acid stones varies from brittle and crumbly to fairly hard. Stones of uric-acid salts are quite hard. Stones of oxalate of lime are usually very hard. Ultzmann pointed out that the hard stones consisted largely of needle-shaped crystals which tended to interlock, and that soft stones consisted of larger prismatic crystals which did not tend to cling together. Phosphatic stones are usually very soft; only rarely, when they consist of crystalline phosphate of lime or of crystalline triple phosphates, they may be hard. The surface of uric acid and urate stones is usually smooth, sometimes rough. Oxalate stones are rough and have a warty, uneven surface (mulberry calculus).

Chemical Examination of Calculi (*partly adapted from Ultzmann*).—Calculi may be examined chemically by sawing the stone into halves. If the stone appears to consist of but one ingredient, the sawdust may be used for chemical examination. If the stone consists of several layers, a small bit may be picked out or scraped away with the point of a knife from each layer and examined separately. In the former method the various ingredients may be determined, but to determine how they are arranged the second method is necessary. In order to distinguish the several layers, Ultzmann recommended that the sawed surface of the stone be polished on a whetstone, cleaned with water, then with chloroform, in order to bring out the borders clearly.

Some of the powdered stone is placed on a platinum spatula and heated over a Bunsen burner slowly to a red heat. Ultzmann called attention to the fact that if the powder is incombustible, it nevertheless will undergo a peculiar series of color changes owing to the content of organic matter. The changes are simply that the powder turns first black, then gray. These changes occur even in pure white phosphates and enable us to distinguish a true concretion from a stone produced for purposes of deception by an hysterical individual or malingerer, and alleged to have been passed *per urethram*. The following schema (page 584) from Ultzmann gives in brief the method of analysis. Those who desire further details are referred to Ultzmann on "The Urinary Bladder"; Ferdinand Enke, Stuttgart (1890, *ibid.*), on "Urinary Concretions."

A more accurate diagnosis of the composition and structure of calculi can be made with the microscope. The method of preparation is briefly as follows: The stone is sawed as nearly as possible through its long axis into two equal sections with a fine saw. If the stone is soft and brittle it may be boiled in Canada balsam before sawing. The sawed surface of one section is polished by hand, using first fine emery powder on a ground glass plate, then water on

THE PULVERIZED STONE OR ITS SAWDUST

Burns Completely.	The powder burns without visible flame and without odor.	The murexid test turns with ammonia purple-red. With KOH purple-violet.	Uric acid and Uric-acid salts.
		The murexid test with ammonia yellow, with KOH orange.	Xanthin.
	The powder burns with a feeble blue flame and gives off an odor resembling burning sulphur, or fat, or like asafetida.		Cystin.
Is Incombustible.	The native powder effervesces with HCl.		Calcium carbonate.
	The native powder does not effervesce with HCl.	The heated powder effervesces with HCl.	Calcium oxalate.
		The heated powder does not effervesce with HCl.	Earthy phosphates.

a fine hard whetstone, until a highly polished surface is produced. The surface is cleaned first with water, then with chloroform. A portion of Canada balsam is then placed upon a suitable microscope slide and heated. The polished surface of the stone is then firmly pressed into the heated balsam. The balsam is allowed to harden. The major portion of the stone is then sawed away, leaving as thin a layer as possible of the stone upon the glass. This sawed surface is then polished as before. When by microscopic examination one sees that the section of stone is thin enough (according to Ultzmann the section should be thin enough to permit the use of an objective giving a magnification of 300 diameters) its surface is cleaned with a camel's hair brush, first with water and then with chloroform. Canada balsam in chloroform is used as a permanent mounting material and is covered with a cover-glass. A number of interesting data are to be derived from microscopic study of thin sections of vesical calculi. (See Ultzmann, "Die Harnconcretionen des Menschen," etc., Wien, 1882; Toeplitz and Deuticke).

The crystalline forms as seen in these sections differ from those seen in urinary sediments. The crystals are either prisms or needles. Stones composed of the former type are soft, of the latter hard. Stones of pure calcium and magnesium phosphates, of sodium urate, and of oxalate of lime are hard stones; when viewed under the microscope by polarized light they are seen to consist of fine needles. Stones composed of uric acid, cystin, and of mixed earthy phosphates are composed of large prismatic crystals, or of such crystals mixed with amorphous materials. These stones are soft and crumbly.

The Nuclei of Calculi.—Cystin calculi and the soft phosphatic calculi, such as are formed in ammoniacal urine, possess no evident nucleus. All other calculi have one or several central masses upon which the outer layers of the stone have been deposited. Such nuclei may be minute or as large as a pigeon's egg. Uric acid and its salts form the nuclei of stones much more often than other ingredients. Thus Ultzmann examined the nuclei of 545 calculi, and found as a nucleus uric acid or urates 441 times; oxalate of lime, 31 times; earthy phosphates, 47 times; cystin, 8 times; foreign bodies, 18 times.

Spontaneous Fracture of Vesical Calculi.—It occasionally happens that calculi split up spontaneously in the bladder into two or more fragments. The lines of fracture are usually radiating, thus producing more or less wedge-shaped fragments; such fractures are confined almost exclusively to uric-acid stones. This has been explained upon the ground that sudden diminution of the specific gravity of the urine, as from drinking large quantities of water and a change in its reaction, might cause the colloid material constituting the matrix of the stone to imbibe urine and to swell. The nucleus becoming thus enlarged might burst the surrounding layers (Ord).

Ultzmann believed that spontaneous fracture of uric-acid stones only occurred when a soft porous intermediate layer existed of ammonium urate, and thought that the contained urea was decomposed into ammonia and carbonic acid, probably as the result of bacterial activity in alkaline urine. The ammonia uniting with the surrounding layer of uric acid would produce soft ammonium urate, the free carbonic acid would then break through this soft layer. The process might be repeated until the stone was disintegrated into several fragments. Disintegration of small uric-acid stones may take place by slow solution in the presence of artificially induced alkaline urine. When spontaneous fracture occurs, each fragment may form the nucleus of a new calculus. Unfortunately, spontaneous disintegration of bladder stones is without much practical bearing on prognosis. Stones are rarely broken up in such a manner that the fragments can be passed *per urethram*.

Occurrence and Etiology.—For the formation of calculi it is assumed that from diathetic or other causes the urine contains an abnormally large quantity of some ingredient, and that further there must be present some foreign body —a blood clot, a blood corpuscle, a fragment of dead tissue, a dead epithelial cell, a hairpin, or what not—upon which crystallization takes place. This may occur in the kidney or in the bladder. Among infants, uric-acid infarcts which are not properly eliminated at birth may cause renal, or later bladder, calculi. They consist always of sodium urate. Their occurrence is rare. During adult life, when the muscular power of the bladder is strong, calculi coming down from the kidney are usually passed through the urethra at once, unless they are too large to go through the canal. Thus many persons who have an abnormal quantity of uric acid, oxalate of lime, or, more rarely, phosphates in the urine, suffer from what is known as urinary sand or gravel. If the bladder is sufficient the fine material is passed *per urethram*, and vesical calculus does

not result; but during advanced age, when the bladder is insufficient from prostatic obstruction, or earlier in the presence of stricture, or at any age when the bladder is paretic, such is not the case. Then the calculus is retained in the bladder and becomes the nucleus of further stone formation. Thus, in males, calculus is observed in early childhood and in advanced age more often than during middle life, except in cases of stricture and in paretic conditions of the bladder. In women, on the other hand, the urethra is short and wide, obstructive lesions are extremely rare, so that they seldom suffer from stone in the bladder unless a foreign body is present to form a nucleus.

Diathesis.—The gouty diathesis and the cystin diathesis are predisposing causes of calculi. Both may be hereditary; the latter, though rare, to a more marked degree than the former. This hereditary tendency in certain families to the formation of cystin and uric-acid calculi is quite marked, though of other calculi it does not obtain. Thus Poland found that among 22 cystin calculi, 11 occurred in 4 families. Teale found cystinuria in 3 members of the same family. The habits of life have some bearing upon the occurrence of calculi. Among the neglected and ill-nourished children of the poor, it was observed by Thompson, in England, that calculi were more common than among the children of the well-to-do. In elderly men, on the other hand, who eat and drink much and exercise but little, calculi of uric acid and oxalate of lime are rather frequent. Among the elderly, however, insufficiency of the bladder from various causes, with its attendant residual urine and ammoniacal cystitis, accounts for a large number of bladder stones.

Climatic and Telluric Conditions.—Calculi occur in every land. They are, however, much more frequent in certain localities than in others. The reasons for this are for the most part obscure. In the countries where Bilharzii hæmatobia and Filaria sanguinis hominis are endemic (Egypt, India, etc.), calculi are exceedingly frequent, from evident causes (see sections on these diseases). On the western coast of the United States, notably in California, oxalate of lime calculi are very common. Chismore attributed this to the large quantities of fruit habitually consumed by the people.

Size of Bladder Stones.—In the East (Egypt, India) and in some other countries where, among the poor, calculi are very numerous and *surgeons* relatively few, bladder stones have been removed weighing from 20 to 30 ounces. In America, stones of great size are extremely rare. A stone weighing 5 to 6 ounces is unusual, and many surgeons of large experience have never removed one of such a size.

Symptoms and Diagnosis of Stone in the Bladder.—The symptoms of vesical calculus, after the stone has reached a certain size, are usually quite characteristic. They consist of painful and frequent urination, most marked when the patient is up and about, less marked or absent when he is in bed, and of hematuria. While the stone is small the symptoms will depend to a great extent upon its shape, its surface, and its weight. Smooth, light calculi of uric acid or cystin may give few symptoms so long as they are small. Rough calculi,

such as heavy oxalate stones and phosphatic calculi, the surface of which resembles sandpaper, produce marked disturbance while yet small. Calculi in diverticula, which are fixed and do not move about in the bladder, may produce few or no characteristic symptoms (Ultzmann). The most prominent symptoms produced by calculi are pain and frequent urination. The pain may be continuous while the patient is in motion. It is always felt during urination, and is most severe at the end of this act, as the wall of the bladder closes down upon the stone. At this time the pain is spasmodic and often excruciating. The straining which accompanies this spasm is attended by rectal tenesmus, sometimes with the passage of flatus or feces. Hemorrhoids and rectal prolapse are prone to develop. *Rest* and the *recumbent* posture cause subsidence or disappearance of the pain, while *active movements* of the body increase it. Riding, driving over rough roads, and jumping, render the pain much more acute. In many cases active movements cause the urine to be tinged with blood. If the patient keeps quiet the macroscopic hematuria may cease. The pain is felt along the course of the urethra, in the glans penis and rectum; it may radiate into the testes, groins, and thighs. It frequently causes the patients to pull upon the foreskin after urination. In children this may lead to priapism and the habit of masturbation. If the stone has been present for some time the elongation of the prepuce, produced by frequent traction, may be quite marked. The patients who suffer the most severe pain are those in whom the stone is either constantly, or during urination, in contact with the trigone or internal urinary meatus. If the stone lies in a retroprostatic pouch and does not come in contact with the internal meatus, the spasmodic pain at the end of urination may be less marked or absent. Some patients can urinate with less pain while lying upon the back. In some cases severe pain is caused by turning over in bed. The patients feel that a foreign body is rolling about in the bladder, and have a sharp or burning pain, often referred to the rectum.

Frequency of Urination.—Frequency of urination varies in different patients. It is greater when the stone lies in contact with the vesical neck and is rough, less marked when the stone is smooth and lies habitually elsewhere. It is more marked in the daytime, when the patient is up and about, and may be absent at night when the stone no longer lies in contact with the trigonum. It is a symptom more marked in the young than in the old, since in youth the internal meatus is at the dependent portion of the bladder; in old age, with the development of a prostatic pouch, the stone rests in that. In some cases the increased frequency during the day and its diminution at night permits a guess as to the probable diagnosis of stone, rather than of prostatic hypertrophy, in which the opposite condition usually obtains.

Sudden Interruption of the Stream.—When the stone lies free in the bladder, notably in the young, sudden interruption in the stream of urine is often caused by the stone rolling against the internal meatus and closing it like a ball valve. The stoppage is attended by a spasm of pain. If the patient shakes himself or bends sidewise the stone is displaced, the stream is reëstablished, is

again stopped, etc. In the aged this is not likely to occur, nor does it occur in those cases where the stone lies partly in the urethra. In these the stream is feeble from the mechanical obstruction from the start, and the patient must strain throughout the act to empty his bladder. In a few cases such a stone may cause incontinence or retention of urine.

Hematuria.—Blood in the urine is one of the regular symptoms of stone in the bladder. It is usually small in amount, often microscopic, but its presence is very constant. When present in considerable quantities the urine may be smoky or slightly tinged with red; often the last few drops will be distinctly bloody. As stated, the amount of blood is increased by exercise.

Pyuria.—Cystitis is one of the regular results of vesical calculus. It may be slight, moderate, or severe, the last when the bladder has been infected by instrumentation with the production of ammoniacal urine. So long as the urine remains acid the cystitis may be only moderate. If the urine is ammoniacal and the stone has an outer layer of triple phosphates, it will be severe.

Ammoniacal decomposition is produced in most cases by catheter infection, and is in no wise dependent upon the size of the stone. Hence calculi of triple phosphates are usually found in bladders which are paretic, or insufficient, from prostatic obstruction or stricture.

In cases of vesical calculus, as in other irritative processes of the bladder, as well as in many other inflammatory lesions not connected with the genito-urinary tract, there may be renal hyperemia and congestion. As a consequence the cystitis of vesical calculus may be accompanied by an albuminuria in excess of that furnished by the pus. In most of these cases the microscope confirms the renal origin of the process—i. e., renal epithelia and casts are found in the urinary sediments. After the removal of the stone the renal albuminuria and renal elements may disappear from the urine.

In addition to organic material, crystals are commonly found in the urine. From the character of these crystals we may make a fair guess as to the composition of the stone, or at least of its outside layers.

The Signs of Stone in the Bladder as Recognized by Physical Examination.—The above-described symptoms of stone in the bladder serve for a probable diagnosis, but many of them may be present though no stone exists. The positive diagnosis is to be made in several ways. In children and in slender adults a stone may sometimes be felt by combined rectal and abdominal touch, or, if the stone be large, by rectal touch alone. Such conditions are, however, exceptional. The following methods are those most generally useful: (1) Examination with the searcher; (2) with the evacuator and lithotrite; (3) with the cystoscope; (4) with the X-rays; (5) by the finger introduced through the urethra of females or through a perineal or suprapubic incision in males.

Examination with the Searcher or Sound.—For the technic of introduction, see Examination of the Bladder. In sounding for stone it is well to have about four ounces of fluid in the bladder at the start. With the Otis searcher

this quantity may be increased or diminished at will. If anesthesia is desired, the deposition of 20 minims of a four-per-cent solution of cocain in the prostatic urethra by means of Ultzmann's drop syringe (see Fig. 76, page 336), and of half the quantity in the anterior urethra, will furnish a sufficient degree of local anesthesia in five minutes. If the patient is very sensitive the bladder may be emptied through a soft catheter, and 4 ounces of a 0.5-per-cent solution of cocain may be introduced into the bladder, and the examination conducted in this medium. If ulcerated surfaces are present in the bladder this quantity might be dangerous. (See Absorption Test for Raw Surfaces in the Bladder.) The sound once in the bladder, the manipulations are as described under Examination of the Bladder. Usually the stone will be struck at once, or during these manipulations. If not, the recess behind the prostate, present in prostatic enlargement, should receive careful attention. The instrument, beak upward, is withdrawn until it brings up against the symphysis. The beak is then slowly rotated backward, and the postprostatic pouch carefully examined. When the stone lies in this pouch, it will be found to the *right* of the median line more often than elsewhere. When the beak of the instrument strikes the stone, the surgeon becomes aware of it in two ways—by hearing and by touch. A sharp click is heard if the stone be hard, audible sometimes at a distance of several yards (oxalates and urates). The click may be elicited repeatedly by rotating the instrument so as to strike the stone a series of slight taps. If the stone be soft (phosphates or cystin) the sound is not so marked; the surgeon depends more upon the sense of touch. The sound may be magnified by a stethoscope attachment to the searcher, or by clamping a thin disc of wood to the shaft of the instrument. These devices are not necessary, though the latter is useful to demonstrate the presence of stone to a large audience.

The *sensation* transmitted to the hand through the searcher is a harsh grating which varies in character with the surface and hardness of the stone. If the searcher be drawn across the surface of an oxalate stone the hard, uneven quality is distinctly transmitted to the hand. If the stone is smooth, merely a firm sense of resistance is felt which disappears as the border of the stone is reached. It is highly important to recognize whether the stone is movable or fixed, since, if the latter, it must be removed by a cutting operation, and cannot be safely crushed. This can usually be recognized easily by pushing and prying the stone about with the beak of the instrument. If it does not seem to be movable, the patient may be shaken rather violently or turned upon his face, or put in the genu-pectoral position or in the Trendelenburg posture, in the hope of dislodging the stone, the searcher again introduced, and the bladder again examined. Stones fixed in the bladder wall or pocketed in a diverticulum may be quite inaccessible to the searcher, but can usually be discovered by the use of the cystoscope with certainty, and even photographed. The *symptoms* accompanying stones in diverticula are the symptoms produced by the infected diverticula rather than those characteristic of stone—i. e., marked cystitis and frequent urination but no bleeding, even after exercise.

Fixed stones, if large, may, as already indicated, sometimes be recognized by bimanual palpation. If the searcher touches a fixed stone, the determination of its actual size demands the use of the cystoscope. Small stones in diverticula may sometimes be sucked out into the main cavity of the bladder by the use of an evacuator. The diagnosis of small stones hard to touch with a searcher may also be made in this way. As the water rushes out through the tube, the stone strikes its eye with a sharp, audible click. Fallacies are, however, possible. If air is contained in the bladder or evacuator, its bubbling will hide the sound made by the stone. The bladder wall may be sucked into the eye of the instrument, and if any of the joints of the apparatus are loose, the shock may cause a click at the loose connection. With the searcher the size of the stone may be roughly measured. After touching the stone the searcher is pushed onward, continually tapping the stone until its posterior border is passed. A bit of rubber band on the shaft of the instrument is pushed into contact with the urinary meatus, and the searcher is slowly drawn out, continually tapping the stone until its anterior border is passed. The distance the instrument has been withdrawn measures one diameter of the stone. The presence of more than one stone may be determined as follows: If one gets a click on both sides of the bladder as the searcher is rotated from side to side, two stones are present. If a *lithotrite* is used as a searcher, a stone firmly

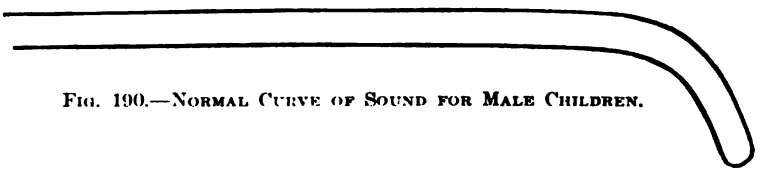


FIG. 190.—NORMAL CURVE OF SOUND FOR MALE CHILDREN.

grasped in its jaws, and the instrument upon rotation elicits a click, two stones are present. If a click occurs on *both* sides of the bladder, three stones are present. A small lithotrite makes a good searcher, and with it the size of a stone can be accurately measured; moreover, upon gripping a stone and giving it a pinch, enough material will stick to the jaws of the instrument for a chemical analysis.

In general the searcher is an entirely efficient means of diagnosis in skilled hands. Some of the possible difficulties are as follows: If the bladder contains more than 175 c.c. of fluid, and the stone is small, it may be missed. A very light stone may be displaced by the searcher without giving a definite sense of impact. The stone may be so thickly coated with blood and mucus that it fails to give a characteristic sound or sensation. Stones in pouches and diverticula may sometimes be brought within reach of the searcher by a finger in the rectum. W. K. Otis was able to detect stones in several cases with the flexible spiral metal prostatic catheter, where the ordinary searcher had failed to find them. In cases where a stone is impacted, part of it lying in the bladder, part in the posterior urethra, the searcher will strike it and usually cannot

be made to pass. In some cases, under a general anesthetic, such stones can be pushed into the bladder and crushed, in others a cutting operation is necessary. One possible source of error in sounding is when an ulcerated new growth is coated with phosphates. It may give the sensation of a stone. The fact that the sound finds the tumor always in the same place, the strong tendency of such tumors to bleed when disturbed mechanically, and the use of the cystoscope, will usually render the diagnosis clear. Some of the characteristic symptoms of stone are usually wanting.

The Cystoscope.—The cystoscope enables the surgeon to see small stones and fragments left after litholapaxy, and to detect encysted stones or stones in diverticula and pouches. When a stone is actually seen in the bladder

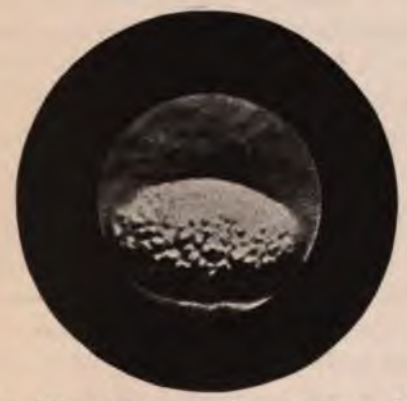


FIG. 191.—CYSTOSCOPIC PICTURE OF A URIC-ACID CALCULUS. (Nitze.)

FIG. 192.—CYSTOSCOPIC PICTURE OF A CONGENITAL DIVERTICULUM OF THE BLADDER, CONTAINING A STONE. (Nitze.)

and recognized as such the diagnosis is certain. The number of stones present can also be counted. The size of a stone seen through the cystoscope is apt to be overestimated by beginners. The accompanying photograph of a vesical calculus was taken by Nitze (Fig. 191).

The X-rays in the Diagnosis of Bladder Stones.—It is a far more simple matter to make a good radiograph of a vesical calculus than is the case with kidney stones. The technic is simple. The patient lies on his back or belly upon the plate, and the tube is placed just above the pubes or over the sacrum, as the case may be. A tube of moderate resistance is used, and with the best apparatus an exposure of a minute or two should suffice for a well-nourished adult. It is to be borne in mind that here, as in the kidney region, *pure uric-acid* stones cast but faint shadows and will often be missed, even though of considerable size, and this with the best apparatus and in the most skillful hands.

CHAPTER XXIX

TUBERCULOSIS OF THE BLADDER

Occurrence.—Primary tuberculosis of the bladder is so exceedingly rare that its occurrence is doubted by many observers. Even in acute general miliary tuberculosis tubercles are rarely observed in the bladder. It was formerly held that tuberculosis of the kidney was frequently due to an ascending infection from the bladder. We now know that such is not the case, and that ascending infection is very rare.

Frequency of Bladder Tuberculosis.—G. Walker (*Annals of Surgery*, February, 1907), among other statistics, gives those of Saxtorph, who found, in 10,016 autopsies, 547 instances of tuberculosis of the genito-urinary organs. There were 342 instances of acute miliary processes in the kidney, but only 4 of miliary tubercles in the bladder. In 205 cases of chronic genito-urinary tuberculosis, the bladder was involved *alone* only once, but in 52 cases there was secondary implication of it—i. e., in 38 men (622 autopsies) and 14 women (3,894 autopsies). In the 38 men the kidney was implicated 32 times, the prostate 29 times, and the seminal vesicles 20 times. In the 14 women the kidney was tuberculous 13 times and the genital organs 3 times. "In 31 cases of genito-urinary tuberculosis noted by Goldberg the bladder was implicated in 23. There were 35 bladder infections in 51 cases of renal tuberculosis studied by Gaultier. Jullien, in 41 cases of tuberculosis of the prostate, found the bladder involved in 13. Israel operated upon 23 cases of tuberculosis of the kidney; the bladder was infected in 11."

Much the most frequent origin of bladder tuberculosis is a descending infection from the kidney. Next in frequency is primary tuberculosis of the epididymis, extending through the vas deferens to the seminal vesicles, thence to the prostate, prostatic urethra, and bladder. Occasionally the disease is primary in the seminal vesicle and prostate, and thence invades the bladder. In descending infections the bladder may be infected by continuity of structure, the disease traveling down the ureter or by inoculation of the bladder by the bacilli contained in the urine. When the prostate is involved the urethra may be first infected or the bladder itself by continuity of structure. Tuberculosis of the lungs and of bone are sometimes followed by tuberculosis of the bladder.

Etiology.—That the bladder is very resistant to invasion by tubercle bacilli is shown by the fact that in renal tuberculosis the urine may contain bacilli for

years without infecting the bladder. This resistance has been proven experimentally many times. If the vesical mucosa is wounded the resistance is much diminished. In the presence of a tuberculous kidney or epididymis, gonorrhea predisposes to tuberculous infection of the bladder. I have often noted that in tuberculous individuals, gonorrhea runs a peculiarly severe course, is apt to become chronic, and to render latent foci of tuberculosis active, whether situated in the genito-urinary tract or elsewhere. I have seen a number of rapidly fatal cases of genito-urinary tuberculosis follow gonorrheal infection in young men. Whether ordinary cystitis due to pyogenic microbes predisposes to bladder tuberculosis is not definitely known. Certain it is that in the vast majority of cases tuberculosis of the bladder is preceded by tuberculosis of the kidney or epididymis. Tight stricture of the urethra and stone in the bladder both predispose to bladder tuberculosis in the presence of tuberculosis of other parts of the genito-urinary tract.

Sex.—Bladder tuberculosis is rather more frequent in males than in females. The exact proportion varies in the statistics of different observers.

Age.—The disease is most frequent during the second, third, and fourth decades of life, but has been observed at all ages.

Pathology.—The trigone, the orifices of the ureters, and the borders of the internal urinary meatus, together with the prostatic urethra, are the parts first affected in most cases. The disease has been observed in a few cases as a tuberculous ulceration of the body and apex of the bladder, without involvement of the base or trigone. The invasion of the bladder is followed by the formation of tubercles from miliary to submiliary size, around the ureteric orifice or in the trigone, or other part. The tubercles are usually grouped, and soon coalesce, forming an area of infiltration from a quarter to half an inch in diameter, creating a prominence in the mucous membrane covered by partly intact, partly necrotic, epithelium. Ulceration follows. The ulcers are at first minute from the breaking down of single tubercles; they soon coalesce. At first they are limited to the mucous and submucous coat, occasionally the muscular wall of the bladder is exposed, later it may be eroded or even perforated. The ulcers are rounded or irregular in shape, with ragged, worm-eaten, undermined borders. Surrounding the ulcer is a reddened border of congestion without visible blood-vessels. A second surrounding area permits the dilated vessels to be recognized. The base of the ulcer is covered with pale pink or pearly gray tuberculous granulation tissue. In many cases groups or rows of tubercles may be seen in the surrounding mucous membrane. Several such ulcers may be present side by side. In the earlier stages of the disease the remainder of the bladder may appear normal. As the process advances the muscular wall of the bladder is exposed or invaded. The ulcer then appears deeper; ragged projecting fragments of muscular bundles may be seen in its base. Sometimes from the sides and base of the ulcers vegetations of tuberculous granulation tissue sprout up, forming papillomatous projecting masses. As the result of the frequent straining, the muscular wall of the bladder during this stage of the

disease is usually moderately hypertrophied. As the disease advances, more and more of the bladder comes to be involved with the production of an intense generalized cystitis. The infiltration comes to involve the entire muscular wall of the bladder, with loss of contractile power from the production of new connective tissue, and atrophy of the muscular bundles. The bladder thus becomes thickened and contracted. At this stage the bladder may hold only an ounce or two of urine, or at most but a few ounces, so that the pain, frequency, and straining become more and more marked. In a case under my observation, a man upon whom a suprapubic drainage opening had been made for the relief of suffering, the entire mucous membrane of the bladder was destroyed and converted into a single ulcerated surface. The wall of the bladder was thickened and as unyielding as leather. Other cases are described in which the proper coats of the bladder are destroyed, but without the production of much inflammatory thickening; the bladder comes to consist of a noncontractile, flaccid bag lined with a granulating membrane. In a few cases the process is intense and acute from the start, the entire bladder is soon involved, the tuberculous tissue rapidly undergoes caseation, with total destruction of the bladder, leaving behind a small cavity lined by cicatricial tissue merely, in which no tuberculous tissue remains. Such lesions are produced by mixed infection of the bladder with virulent tubercle bacilli and pyogenic cocci in individuals with feeble resistance. They are rare. Caspar has described a type in which the entire bladder is acutely invaded with the production of an intense cystitis. It is generally regarded as a mixed infection.

Location of the Lesions.—In the vast majority of cases the disease begins in or near the trigone. Isolated cases have been described of tuberculous ulcers situated in the upper part of the bladder. When infection occurs from the kidney the ureteric orifices are regularly first involved. (See Renal Tuberculosis, Cystoscopic Examination, Urethral Catheterization.) Occasionally, instead of spreading into the trigone, the prostate is next invaded. In most cases the trigone and the posterior or anterior bladder wall are subsequently invaded. When the invasion comes from the prostate, the prostatic urethra, internal urinary meatus, and trigone are the usual seats of invasion. Perforation of the bladder wall is relatively rare. The following conditions have, however, been observed: Perforation into the space of Retzius with abscess formation; through the umbilicus, into the general cavity of the peritoneum, into the rectum, the vagina, the groin; perforations through the base are much the most frequent and produce a communication between the bladder and the rectum. Abscess of the prostate is not uncommon. (See Prostate.)

Symptoms and Diagnosis of Tuberculosis of the Bladder.—As stated when describing renal tuberculosis, tuberculosis of the kidney is often mistaken for disease of the bladder. The former may produce all the symptoms of the latter —namely, painful and frequent urination, pyuria, hematuria, and tubercle bacilli in the urine. At the outset, therefore, it may be remarked that the most certain means of diagnosis, in the earlier stages of the disease, is by means of the

cystoscope, through which the nature of the lesions can be readily recognized if present, or their absence demonstrated. In the later stages, when the bladder is contracted and the seat of an intense mixed cystitis or of a generalized ulceration, the use of the cystoscope is rarely practicable. In these cases the bladder in women is still open to direct inspection through Kelly's tubes. In men the presence of a tuberculous epididymitis and of nodules in the prostate will aid in the diagnosis. If, in addition, the patient has very frequent and very painful urination, and if upon injecting fluid into his bladder its capacity is found to be greatly diminished, the diagnosis of tuberculosis of the bladder is almost certain. If the prostate, seminal vesicles, and epididymes are found free, and if an enlarged and tender kidney is felt in the loin, with a positive finding of tubercle bacilli in the urine, then the more marked the bladder symptoms the more likely that the bladder is also diseased. When the prostate is affected without the bladder, the diagnosis of the condition of the bladder without cystoscopic examination is difficult except by suprapubic incision and direct inspection of the bladder.

History of the Development of the Disease and the Symptoms in Detail.—The symptom-complex of bladder tuberculosis consists of painful and frequent urination, hematuria, and pyuria. In the later stages of the disease anemia, loss of flesh and strength, accompanied by irregular fever and occasional chills, finally exhaustion and death from toxemia, loss of sleep, pain, etc.

Disturbances of Urination.—Since the kidney is first affected in many cases there will be polyuria. The quantity of urine may also be increased by reflex irritation from the bladder. (See Polyuria in Renal Tuberculosis.) In the majority of cases the patient will gradually develop frequency of urination day and night. After weeks or months pain will be added during urination, and a continual dull sense of discomfort in the sacral region. The pain and frequency are influenced neither by rest nor by exercise. As time goes on the pain and frequency will increase; the patient may be obliged to urinate twenty or thirty times a day, and always with steadily increasing discomfort, until in the advanced stages of the disease, spasmodic pain of an agonizing character will be felt almost continuously. The acts of urination may be repeated every five minutes. The pain is most severe when the prostatic urethra and internal urinary meatus are affected. In these cases the mortal agony endured is not exceeded by any other form of suffering. In the rare cases where the disease is confined to the upper part of the bladder, pain is by no means so marked, and may even be absent. In exceptional cases the onset of the disease is characterized by painful and frequent urination of an intermittent character, lasting for days or weeks, subsiding and recurring after longer or shorter intervals, sometimes months, even years, finally to become continuous and more and more severe. The pain is felt during urination along the urethra and in the glans penis, and is of a burning character. In addition there is severe spasmodic pain at the end of the act felt in the glans and prostate, as the sphincter squeezes the inflamed or ulcerated prostatic urethra. The pain continues as a burning

sensation in the perineum for several minutes after urination, and slowly subsides, to be renewed when the patient is again obliged to urinate. In rare cases there is frequency but no pain. In others pain may be the initial symptom before any frequency is observed. In advanced cases the pain is continuous and may radiate to the kidney region or into the groin and thighs.

Hematuria.—In about ten per cent of the cases an attack of hematuria is the initial symptom. It may be slight or severe, and may or may not be accompanied by pain. For the differential diagnosis between renal and vesical hematuria, see Kidney and Cystoscope. In some cases a number of attacks of hematuria will occur at intervals, before any symptoms of bladder irritation develop; such intervals may be weeks, months, or even years. During the early stages of the disease these attacks of bleeding are very common. Usually the amount of blood lost is small. In the later stages there may be no hematuria, but when the prostatic urethra is ulcerated hemorrhage is almost sure to occur. I have seen such patients who bled at every urination for many months. In the later stages deep ulceration of the bladder wall may erode a vessel of some size and cause serious, even dangerous, bleeding, though this is rare.

The Urine.—The quantity of urine passed does not vary from that observed in kidney tuberculosis—i. e., there is moderate polyuria, as a rule. The presence of tuberculosis appears to be inimical to alkaline fermentation of urine, so that an acid reaction is usually preserved except in advanced cases with mixed infection. Unless the kidney is also involved there are usually no marked changes in the specific gravity, content of urea, and salts. (See the Urine in Renal Tuberculosis.)

Tubercle Bacilli.—Tubercle bacilli may be found in a proportion of cases which vary directly with the patience, care, and skill of the observer. (See Tubercle Bacilli in Urine.) The presence of bacilli, however, does not establish the exact site of the disease.

Pyuria.—In the early stages, if the kidney is not furnishing pus, the urine may be clear, or only show the evidences of a slight catarrhal cystitis—namely, pus cells and epithelia from the bladder in moderate number. Later, blood will appear and the quantity of pus will steadily increase with the progress of the disease. In the later stages, cheesy material, bits of necrotic mucous membrane, or even muscle, may be evacuated. The pyuria will be very marked indeed. The appearance of pyogenic organisms in the urine belongs to the later stages of the disease. In one of my own cases the bladder was extensively ulcerated and streptococci were present in the urine in large numbers. Bacillus coli, the ordinary pyogenic forms, proteus, and others may be present.

The *cystoscopic appearances* in bladder tuberculosis have been sufficiently indicated elsewhere. They are the most certain means of diagnosis.

Incontinence and Retention of Urine.—Among the symptoms which may appear in the course of bladder tuberculosis are incontinence and retention of urine. Several forms of incontinence are possible. The patients may have a constant desire to urinate, so that as fast as a drachm or two of urine collects

in the bladder it is involuntarily expelled. This is common to both sexes in the later stages of the disease. Incontinence from overflow may occur when the patient suffers from retention due to swelling of the prostate. The vesical sphincter may be destroyed by ulceration, producing continuous dribbling of urine. Retention may occur early in the disease from irritation of the prostatic urethra causing spasm of the vesical sphincter. When the prostate is tuberculous the swelling of the gland may cause mechanical obstruction. The not infrequent occurrence of prostatic abscess may cause retention. Rarely the detrusor muscle may be so far destroyed or infiltrated that the patient loses the power to empty his bladder, wholly or partly. As in other conditions a large collection of clotted blood in the bladder or a single firm clot of moderate size may block the urethral orifice.

Disturbances of General Health.—During the early stages, patients retain their flesh and strength, unless other foci of tuberculosis are producing serious toxemia. As the disease progresses and they begin to suffer from constant pain, they become gradually weaker, more and more emaciated and anemic. During the terminal stages the progressive deterioration is rapid. Exceptions occur. I have seen a man with tuberculosis of the bladder and both kidneys who appeared to be in fair health a few weeks before he died.

Fever is rarely present until the disease is far advanced. It may be of a hectic type or an irregular fever of moderate severity, sometimes associated with chills.

Among the symptoms sometimes observed in early tuberculosis of the prostate and prostatic urethra, produced in part by the local irritation, is an increased *libido sexualis*. This may be observed in certain cases even late in the disease when the patients have become weak and emaciated. It is also said to be not uncommon in tuberculosis of the lungs. Some of these patients copulate industriously up to a short time before death.

The recognition of the complications of bladder tuberculosis—perforations, stone, abscess of the prostate, pyogenic infections—is discussed sufficiently elsewhere.

Diagnosis.—Some diagnostic hints, in addition to what has already been transcribed, are perhaps worthy of record. It cannot be too strongly accentuated that, by fairly good observers, diseases of the kidney and of the bladder are often confounded. This applies not so much to the genito-urinary specialist, or general surgeon, as to the average practitioner of medicine. In young adults, when gonorrhea and vesical calculus can be excluded, a slowly developing pyuria with irritation of the bladder is strongly suggestive of tuberculosis of the genito-urinary tract. A careful search should be made in such cases for positive signs of the disease. The lungs, the testes, the prostate, the seminal vesicles, and the kidneys should each receive attention. Cystoscopy will often do much to render the diagnosis clear in doubtful cases. Many varieties of cystitis are quickly improved by local treatment. *Bladder tuberculosis is almost invariably made worse by instrumentation and bladder irrigations.*

Simple Ulcer of the Bladder.—Simple ulcer of the bladder is a rare condition. If situated near the trigonum, the symptoms may resemble those of tuberculosis. The cystoscopic picture will show a rounded ulcer; the base covered usually with clean granulation tissue; the edges not undermined. There will be no scattered tubercles in the vicinity. The shallow, superficial erosions noted in the severer forms of cystitis are part of a diffuse process involving the entire bladder. The erosions will be scattered over the mucosa here and there. Tuberculous lesions in other organs will be absent; pyogenic organisms will be present; tubercle bacilli absent. Stone in the bladder is to be excluded by the searcher and cystoscope. Cancer of the bladder occurs in advanced life. There is bloody urine; later, pyuria. The painful symptoms, however, are usually developed at a stage when either a palpable tumor can be felt or when the cystoscope renders the diagnosis plain. (See Tumors of the Bladder.) Papilloma of the bladder is attended by bleeding; the painful symptoms are usually slight or absent. The cystoscope or the passage of a villous process clears up the diagnosis.

The duration of life varies greatly. In some cases these patients live for many years; in others the progress of the disease is rapid. They may die in less than a year. The average duration of life is about three years.

Treatment of Tuberculosis of the Bladder.—The most hopeful therapy of tuberculosis of the bladder is to remove the other foci, kidney, or testis and epididymis, in other cases prostate and seminal vesicles, and, if he survives, to send the patient to live out of doors under the most favorable hygienic conditions. It is to be borne in mind, that after the removal of a tuberculous kidney the bladder lesions, if slight, improve or get well in many cases. Suprapubic drainage is useful to allay the intolerable suffering of the later stages of the disease.

CHAPTER XXX

TUMORS OF THE BLADDER

The bladder is one of the rarer sites of primary tumor development. The frequency of tumors of the bladder is variously estimated at from 0.25 to 0.40 per cent of all tumors. Primary tumors of the bladder are more than twice as frequent among men as among women. The greatest number occur after the thirtieth year of life. Certain forms are, however, observed only in childhood—i. e., mucous polypi or myxomata. The favorite locality for all bladder tumors is the vicinity of the trigonum and the ureteric orifices; broadly, the lower half of the bladder. As elsewhere, the tumors may be: (1) Primary, in the bladder. (2) Secondary, when the bladder is invaded by tumors originating in neighboring organs; the prostate in males, the uterus and adnexa in females; the rectum. (3) Metastatic. The second group is very common, the third very rare. Thompson observed a metastatic nodule in the bladder in a case of generalized melano-sarcoma originating in the eye.

Secondary Tumors.—The secondary tumors are, for the most part, carcinomata. Bladder symptoms form almost regularly a part of the clinical picture in advanced cases of carcinoma of the uterus and rectum. Cancer of the prostate usually invades the bladder, and the symptoms produced are much the same as those observed in primary cancer of the bladder; often, even at autopsy, we may be unable to distinguish the origin of the growth, except that primary cancer of the prostate usually runs a much more rapid course, and infects the pelvic lymph nodes very early. Primary cancer of the bladder wall is of slower growth, and does not so soon produce lymphatic infection and metastasis.

Primary Tumors of the Bladder.—Primary tumors may belong to many tumor groups. Of these, however, only two are at all common—i. e., benign papilloma or villous tumor, sometimes becoming malignant, and carcinoma. The others are much more rare.

Küster classified primary tumors of the bladder, according to their origin, into (1) tumors originating in the mucous membrane and submucous connective tissue; (2) tumors originating in the infrequent glandular structures of the bladder wall; (3) tumors originating in the muscular wall of the bladder.

Villous Tumor, Papillary Fibroma, Fimbriated Papilloma.—Among the tumors originating in the mucous membrane and submucous tissue, by far the most frequent is the so-called villous tumor, papillary fibroma, fimbriated papilloma. The following brief but classic description was given by Thomp-

son: "The most obvious characteristic of the growth is a structure in which the vesical mucous membrane is developed into fine papillæ, which consist of long fimbriated processes of extreme tenuity, and usually form a group arising from a small circumscribed base. This last-named part contains other and more solid structures than those which enter into the papillæ themselves. Sometimes the processes are almost single, threadlike forms, arranged side by side and undivided for a considerable distance; others are bifid, generally more compound still; some may be described as digitate, and occasionally the processes radiate and suggest forms resembling those of leaves. Immersed in fluid, the long, fimbriated growths float out like slender-leaved aquatic plants in deep water, and when removed to the air collapse and form a soft mass resembling a small strawberry."

The villous tumors appear to possess a peculiar quality of propagating themselves by contact—i. e., where a villous growth has been long in contact with the opposite wall of the bladder, a new tumor may appear at this point.

Under the microscope the tumor is seen to have a basement substance of connective tissue prolonged as delicate processes into the innumerable villi. Each villus contains also a vascular loop, which is prolonged to its tip. The epithelial covering consists of one or several layers of cylindrical, or polygonal, or fusiform epithelial cells. In some tumors the branching is less highly de-

FIG. 193.—VILLOUS EPITHELIOMA OF THE BLADDER. Cystoscopic picture. (Keyes, after Albarran.)

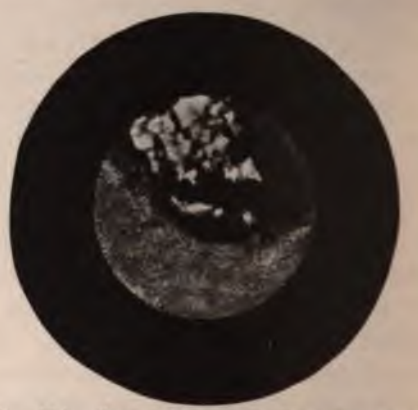


FIG. 194.—SMALL TUMOR OF BLADDER WITH UNEVEN SURFACE. (Nitze.)

veloped, and they may then resemble a cauliflower, a cockscomb, or a raspberry (see Fig. 193, also Fig. 194). For the most part, the villous tumors are pedunculated so long as they remain benign. The connective-tissue stem arises from the submucosa, and extends a variable distance into the interior of the bladder. In some cases solitary or multiple villi spring directly from the bladder wall; such villi or groups of villi may be scattered thickly or sparingly over a considerable surface.

FIBROMA.—Fibrous polypus of the bladder is a rare tumor, and purely benign. For the most part these are pedunculated growths, consisting of firm

fibrous tissue covered by normal mucous membrane. They usually produce no symptoms unless they grow large enough to obstruct the internal meatus like a ball valve.

Polypi.—Soft polypi, mucous polypi, sometimes true myxomata, have been observed in the bladders of children. They occur, as do the fibromata, in the

FIG. 195.—VILLOUS TUMOR OF THE BLADDER. On the right a villous process denuded of epithelium. On the left the same covered with epithelium. (After Ultzmann.)

FIG. 196.—VILLOUS TUMOR OF THE BLADDER MORE HIGHLY MAGNIFIED. On the left a mass of epithelial cells. On the right a large villous process the vessels filled with blood corpuscles. (Ultzmann)

vicinity of the internal meatus. They are, as a rule, pedunculated, and in little girls may prolapse through the urethra. Sometimes such tumors are multiple, and may cover a considerable area of bladder wall.

SARCOMATA.—Sarcomata are very rare in the bladder. Nearly all the forms of sarcoma have, however, been observed in the bladder as massive, sessile, or as pedunculated growths. In one case (Marchand) metastases occurred in the lungs. In general, metastases appear late, if at all. In both carcinomata and sarcomata the patients die rather from the effects of the primary tumor than from generalized dissemination. When the sarcomata are sessile the tumor may reach a considerable size before encroaching much on the bladder cavity. The surface of the tumor is usually smooth; ulceration occurs late, if at all.

MYOMATA.—Tumors consisting of striped, and others of unstriped, muscular fibers occasionally occur in the bladder. They may be sessile or pedunculated. They may be submucous, interstitial, or subperitoneal. Symptoms are rarely produced unless the tumor causes mechanical interference with urination.

Dermoid Cysts.—Occasionally dermoid cysts rupture into the bladder. They are rarely primary in the bladder wall. The ovary is their usual origin. The characteristic passage of hair, oil, etc., in the urine establishes the diagnosis.

Simple Cysts.—Simple cysts of the bladder wall are sometimes observed. They are rarely of much significance.

Echinococcus Cysts.—Echinococcus cysts occasionally rupture into the bladder. The diagnosis is to be made by finding hooklets in the urine. (See Echinococcus.)

FIG. 197.—MULTIPLE VILLOUS PAPILLOMA OF THE BLADDER. Histologically: True benign papilloma. (Albarran.)

The Epithelial Tumors of the Bladder, Adenoma and Carcinoma.—The adenomata may occur in any part of the bladder, even at the apex, where no glandular elements are normally found. The microscopic appearances are those of adenoma, fibro-adenoma, rarely cyst-adenoma, as described under Tumors. They form nodular or flat growths, and may reach a considerable size. They are seldom pedunculated.

Cancer of the bladder may occur in any part of the bladder, though many of them originate in the prostate; though less frequent, they are also observed in women. Primary cancer of the bladder wall occurs for the most part as an infiltrating form of tumor—carcinoma medullare, more rarely carcinoma alveolare, occasionally scirrhus. In the medullary form the tumor invades the muscular wall of the bladder and forms a fungating, ulcerated, nodular, uneven intravesical growth, with necrotic areas here and there. A deposit of earthy phosphates and other salts often occurs upon the raw surfaces. Infiltration spreads slowly until a large part of the bladder is involved. The tend-

FIG. 198.—MYXOSARCOMA IN THE BLADDER OF A YOUNG GIRL HAVING THE GROSS APPEARANCES OF MUCOUS POLYPI. (Afte Albarran.)

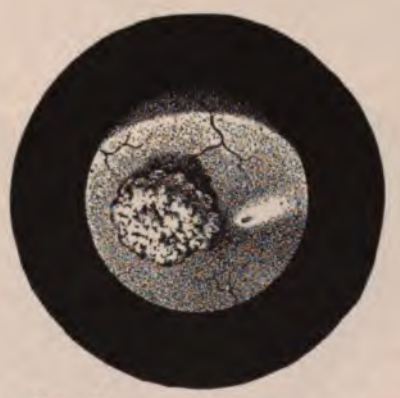


FIG. 199.—LOBULATED EPITHELIOMA OF THE BLADDER. (Keyes, after Albarran.)

ency toward the production of villous projections and cauliflowerlike masses is marked. In some cases the entire bladder is converted into a nonelastic and contracted mass of cancerous tissue. During the later stages hemorrhages into the substance of the tumor, necrosis, deep ulceration, occasionally leading to perforation into neighboring organs, occur. Portions of necrotic tumor tissue may be extruded with the urine. A severe complicating cystitis is usually

developed, leading to the deposition of earthy salts and incrustation of the tumor surface. Pressure upon the ureters is often followed by hydronephrosis or pyonephrosis. Pyelonephritis is a common complication. In those cases where early obstruction to urination occurs at the vesical neck, retention of urine with dilatation and atony of the bladder may take place.

Many carcinomata are believed to result from cancerous degeneration of the base of a villous tumor of the bladder. Clinically, this is a highly important fact to bear in mind. The extirpation of a villous tumor should include a considerable area of apparently healthy muscular wall, since the projecting portion of the growth may be purely a papilloma, while its base has undergone cancerous degeneration, requiring rather liberal extirpation.

It may be well to note here that the views of surgeons are somewhat at variance in regard to the malignant degeneration of villous tumors of the bladder, and as to the relative frequency of benign and malignant growths. Küster, Nitze, and other German surgeons consider that such degeneration is rare, and believe that many really benign villous tumors have been called cancers as the result of the erroneous interpretation of the microscopic appearances. The French school, on the other hand, Guyon, Albarran, and others, as well as many American surgeons, including Keyes, believe that such degeneration is the rule, and that many tumors diagnosticated as papillomata are really cancers from the start, wholly or in part. Thus, among 132 tumors, Albarran found 100 cancers and 24 papillomata.

Symptoms and Diagnosis of Tumors of the Bladder.—Villous Tumor.—The most constant and characteristic symptom of villous tumor of the bladder is hematuria. The bleeding occurs in attacks of irregular duration and at irregular intervals. Neither the beginning, severity, nor duration of these attacks are influenced by exercise or rest, or by medication. The bleeding is as likely to occur in the night, when the patient is asleep, as in the day, when he is working or exercising. The hemorrhage may render a single urination bloody, the next urine passed being clear, or it may last continuously for days, weeks, or months. Usually it stops as suddenly as it commenced, and may not recur for months or even years. The amount of blood lost may be slight, moderate, or considerable. It is rarely so profuse on any one occasion as to induce

Fig. 200.—Alveolar Carcinoma of the Bladder. (After Keyes.)

a profound anemia or endanger life. Usually the larger the tumor the more profuse the bleeding, yet to this rule there are many exceptions; a small tumor may bleed actively. Unless the bleeding is so profuse that clots form in the bladder and cause dysuria or retention, hematuria is the solitary symptom observed, sometimes for a long period. During the attack the urine may be evenly bloody, or in slight attacks the first portion of urine passed will be clear, the last few drachms alone being blood-tinged or consisting of pure blood. The absence of any other symptom but hematuria coming on in the ways described enables us usually to exclude vesical stone as a cause of bleeding. In rare cases, when the tumor, though still small, is so situated that it readily overlies the internal meatus, the patient may have difficult urination, or even retention. In some cases, in addition to blood, the patient will pass fragments of necrotic tumor tissue; less often fresh masses of villi, recognizable as such under the microscope. The particles are usually small, and often pass unnoticed in the urine. In other cases quite large clumps of tumor shreds will be passed at frequent intervals. Cases are recorded where spontaneous cure of small villous tumors has taken place in this way. The whole tumor has been extruded, and has not recurred. In most cases no such cure takes place; new villi sprout from the base of the growth, and the symptoms return. As time goes on, the attacks of bleeding are repeated, and usually become more frequent and severe. The patients become anemic and weak, and are likely to die of intercurrent diseases. The course of the disease is often prolonged over many years. When the tumor grows so large that it interferes with urination, the patients suffer from dysuria, strangury, retention of urine, and are altogether miserable. They often develop nephritis, and may die from combined anemia, exhaustion, from pain and loss of sleep, and uremia. Most of them, as the result of instrumentation, develop cystitis, incurable while the tumor remains. The urine contains blood, pus, bacteria, etc. Sepsis and uremia due to ascending infection and pyelonephritis is the common mode of death.

Fibroma, Myxoma, Cysts, Etc.—Fibroma, myxoma, cysts, myoma, and other rare benign tumors of the bladder, when they produce symptoms at all, do so mechanically. Hematuria is rarely marked. If the tumors grow large, cystitis and ascending infection may occur.

Symptoms of Malignant Tumors of the Bladder.—*Carcinoma.*—The early symptoms of cancer of the bladder are often the same as those of villous tumor—i. e., merely hematuria. The course of the disease may be slow or rapid. In some cases the patients live for years, and of these a certain proportion are surely due to the malignant degeneration of originally benign papillomata. Pain is often an early symptom, on account of interference with the contractile power of the bladder by cancerous infiltration. In addition, there is frequent urination, together with sharp or dull pain, referred to the prostate and sacrum. Some cases are made worse by active motion, suggesting stone. Until cystitis develops, the general health may not suffer. Infection of the bladder is apt to occur earlier than in benign growths, and once developed is of

a severe and horribly painful type. It is in these cases that putrid and gangrenous cystitis are prone to occur. The urine is turbid, dirty green or brownish in color, horribly offensive, and contains tumor *débris*, blood, pus, bacteria, etc. (See Cystitis.) Death occurs from constant pain, exhaustion, pyelo-

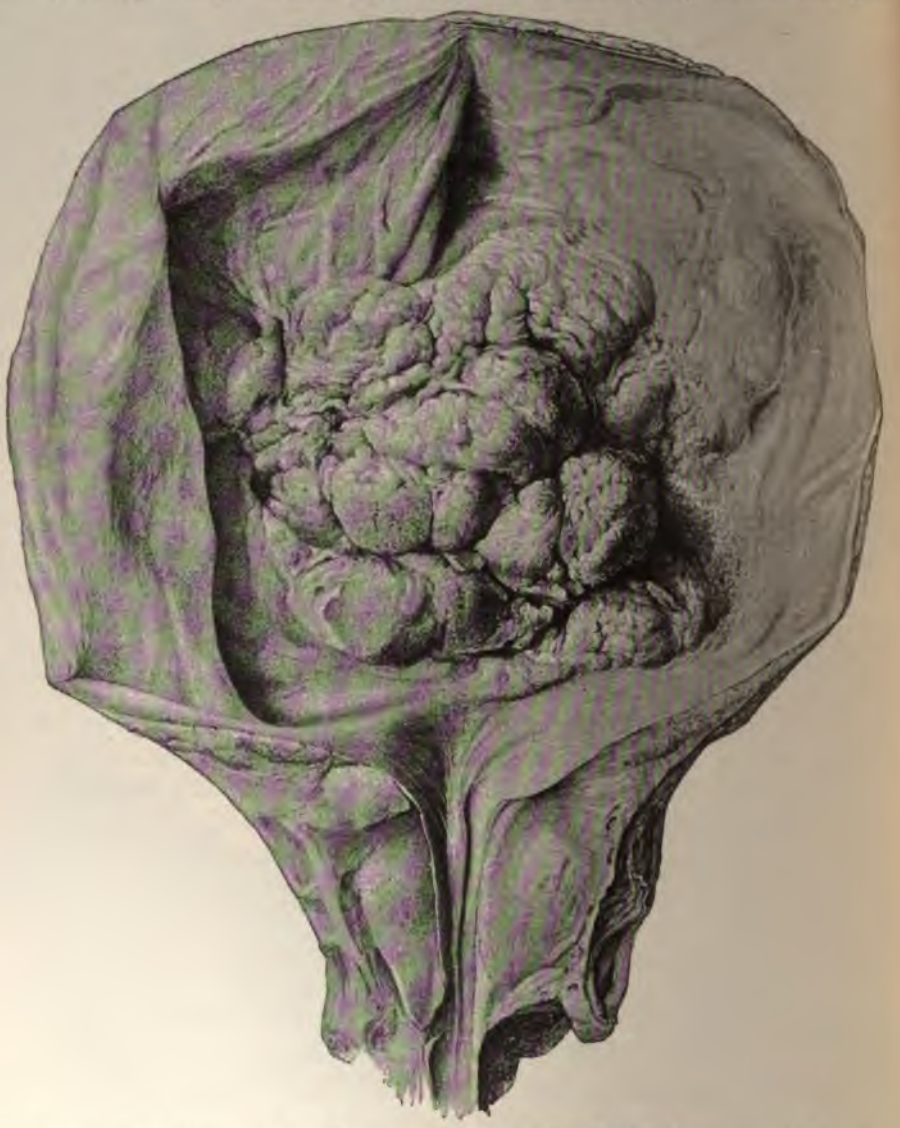


FIG. 201.—CARCINOMA OF THE BLADDER. Histologically: Epithelial cancer. (Albarran.)

nephritis, sepsis, and uremia. Metastases and cancerous cachexia are rarely developed in cancer of the bladder. The local lesions and their complications end life, as a rule. The duration of life in cancer of the bladder is from two to five years.

Adenoma.—The clinical course of adenoma of the bladder resembles that of carcinoma.

Sarcoma.—Sarcoma of the bladder usually produces, at first, mechanical symptoms; in the later stages ulceration and bleeding may occur.

THE DIAGNOSIS OF TUMORS OF THE BLADDER.—The first symptom of tumor of the bladder is in most cases hematuria. The diagnosis is sought for first by finding the source of the blood. (See Hematuria.) The cystoscope is the simplest and readiest means of diagnosis, and in early cases gives beautiful and characteristic pictures. When a tumor projects into the interior of the bladder, its situation, surface, size, etc., can be studied through the cystoscope even better than by direct inspection through a suprapubic opening. This is notably true of the villous tumors. Through the cystoscope the villi can be seen like the branches of an aquatic plant submerged in water. The site of attachment, multiplicity, etc., can be readily studied. When the bladder is opened, these tumors collapse and shrink, so that smaller masses and single villi may be missed altogether. In examining with the cystoscope the following data may be borne in mind: Most tumors grow from the trigone, the internal meatus, or near the mouths of the ureters. Still, all parts of the bladder should be inspected. Papillary forms are common in cancer as well as in benign tumors. A villous papilloma may have a cancerous base. In typical epithelioma and carcinoma the appearances are usually such that they can be distinguished from benign forms (see Figs. 200 and 201).

Bleeding may obscure the field. It may be necessary to keep the patient under observation until the bleeding has stopped. The injection into the bladder of 1 to 2,000 adrenalin solution is sometimes a useful aid. Benign tumors which do not bleed can often be easily studied, and even photographed. In advanced cases it may be impossible to use the cystoscope. In these the history, the symptoms, and the signs, as discovered by other methods of examination, usually establish the diagnosis. In some advanced cases the cystoscope may still be used after gentle and repeated washing of the bladder. The surface of the tumor will be seen coated with flakes of pus, sometimes with earthy salts. Ulcerated and necrotic areas may be seen here and there. Usually the borders of the growth are obscured by the diffuse swelling and congestion of the mucous membrane.

Rectal and bimanual palpation are sometimes useful. Small, soft tumors cannot be felt, but infiltration of the floor of the bladder can readily be felt, and establishes malignancy at once. This sign is valuable when the intravesical projection is small and looks benign through the cystoscope. In such cases rectal touch may reveal infiltration of the bladder wall, and enable the surgeon to avoid a useless operation. In some cases incision into the space of Retzius and bimanual palpation of the bladder will be sufficient to establish the presence of a tumor, and to determine whether or not it is operable. In the former case it may be removed at once.

CHAPTER XXXI

THE PROSTATE

(*Injuries and Diseases of the Prostate Gland*)

GENERAL

Anatomical Remarks.—The prostate is an organ of complicated structure. It belongs to the sexual rather than the urinary apparatus, but is in close anatomical relation to the latter. It is intimately concerned in the formation of the sphincter apparatus of the urinary bladder. It is made up of glandular tissue, and of both smooth and striped muscle fibers. It is perforated by the urethra and by the ejaculatory ducts, the continuation of the vasa deferentia. The prostate is commonly likened in size and form to a Spanish chestnut. It is, roughly, a truncated cone. It has a base directed upward toward the bladder, and an apex directed downward and in contact with the posterior layer of the deep perineal fascia (triangular ligament). The prostate is supported by the pubo-prostatic ligament. The long axis of the prostate is directed downward and forward, and makes an angle of twenty to twenty-five degrees with the vertical. On either side are the rounded right and left lobes, bulging posteriorly into the rectum. At the base a median lobe exists. The median lobe is that portion of the prostate near the base included between the ejaculatory ducts in their passage through the gland. In certain cases of senile hypertrophy of the prostate this portion of the gland may be chiefly involved, and may form a projecting tumor, causing urinary obstruction. The two lateral lobes are united posteriorly behind the urethra by the so-called posterior commissure or isthmus (pars intermedia); a thin layer also covers the urethra in front—the anterior commissure. The anterior surface of the prostate is shorter than the posterior, since the plane of the base passes from behind and above downward and forward—i. e., it is beveled at the expense of the anterior surface.

Size of the Prostate.—The size of the prostate is important, since in old age enlargement of the prostate gives rise to a train of symptoms ending in death unless relieved by surgical means. The diameters of the prostate vary to some extent within normal limits in healthy adult life. As given by Merkel, they are as follows: Basis to apex, 25 to 35 mm.; average, 30 mm. The greatest transverse diameter, 35 to 45 mm.; average, 40 mm. The greatest thickness, 15 to 25 mm.; average, 20 mm.

According to Henle, these figures are rather vague, because the borders of the prostate are not easy to fix exactly in all directions. In front and at the sides the muscular bundles of the prostate lose themselves in surrounding structures. Posteriorly, the most important surface, from a clinical point of view, and the easiest to examine, the prostate is sharply bounded by a smooth, firm layer of connective tissue. The weight of the prostate is from 16 to 20 grams. The consistence of the prostate is firm, but elastic. Its shape may be changed somewhat by pressure and its tissues are very dilatable, as shown during various perineal operations involving a dilating procedure upon the prostatic urethra.

Position and Relations of the Prostate.—When the bladder is full the prostate is depressed, along with the pelvic floor. When the rectum is distended the bladder and prostate are pushed upward. Under ordinary conditions rectal palpation in the knee-chest position will find the apex of the prostate 3 cm. from the anus. When palpating enlarged prostates *per rectum* it is best to have the bladder partly filled, but not distended, with urine. The anterior surface of the prostate is almost vertical, and is distant from the oblique anterior bony pelvic wall, at the middle point, 10 to 12 mm., above more, below less. The intervening space contains a venous plexus and loose, fatty tissue. The lateral surfaces of the prostate are inclosed in a sort of funnel, formed by the levator ani muscle, which similarly incloses the rectum posteriorly. The space between the prostate and levator ani is narrow, contains numerous veins, muscular bundles, and dense connective tissue, uniting the prostate to the muscle. The posterior surface is directed toward the rectum, and has an inclination midway between horizontal and vertical. Prostate and rectum are separated by a dense layer of fascia (fascia rectovesicalis), a layer of loose connective tissue intervening between the rectum and fascia as well as between fascia and prostate. Thus, in the event of a prostatic abscess pointing toward the rectum, unless adhesions occur between these several layers the pus may find its way into the connective-tissue planes of the pelvis. I have seen this occur, though it is rare. The upper border of the posterior surface has often a median notch, thus giving the organ the shape of the heart pip on a playing card. The notch is sometimes prolonged into a median furrow, dividing the organ into a right and left half, or lobe.

The prostatic urethra passes in a gentle curve through the gland. In the upper part it is nearer the anterior surface, in the middle nearer the posterior surface (see Fig. 202). In addition to the urethra, the ejaculatory ducts penetrate the prostate; between them is the vesicula prostatica, sinus pocularis, utricle, a fetal vestige of the Müllerian duct. This is a little pocket in the mucous membrane of the floor of the urethra, situated on the anterior face and below the summit of the verumontanum (colliculus seminalis, caput gallinaginis). The depth of the utricle varies, as is the case with other vestigial structures. In some cases it is a mere dimple, in others 10 to 15 mm. in length. In others it may extend beyond the prostate and appear between the

borders of the vasa deferentia. It is believed that in some cases it may form a considerable cyst between prostate and rectum.

After their entrance into the posterior border of the base of the prostate, the *ejaculatory ducts* converge, and near their orifices are separated only by the vesicula, upon the borders of which they empty by two small orifices.

FIG. 202.—TRANSVERSE SECTION THROUGH MIDDLE OF HUMAN PROSTATE, SHOWING CAPSULE, STROMA, ANTERIOR COMMISSURE, ARRANGEMENT OF GLAND TISSUE IN LOBULES, COMMON EJACULATORY DUCTS, AND UTRICLE. (From Watson, after W. E. Richardson.)

STRUCTURE OF THE PROSTATE.—The prostate consists of muscle fibers, some of which surround the urethra, and of glandular elements. The glandular tissue forms the larger part of the completely developed organ. The glands are of the compound racemose type. The acini are lined with columnar epithelium. The glands are more abundant near the posterior surface of the prostate; in front of the urethra they are scarce or absent; they form the prostatic lobes. Smooth muscle fibers everywhere surround and penetrate the glandular lobules. For this reason the gland, on section, permits no recognition of a lobulated structure, but rather the appearance of a sponge. The glands empty by several minute ducts into the lateral portions of the floor of the prostatic urethra, both in front of and behind the verumontanum. In later life concretions are often found in both glands and ducts. In addition to the muscular bundles in intimate connection with the glandular tissue, the muscle fibers are developed in three separate regions, quite independently of glandular structures—namely, at the base, apex, and anterior surface of the prostate. At the base is the *internal sphincter* (*sphincter vesicæ internus*), a loop of unstriped muscle fibers, somewhat prismatic in shape, which originate in the muscular layers of the trigonum. The loop passes forward across the anterior border of the beginning of the urethra, thence backward again to the trigonum. On the anterior face, and toward the apex of the prostate, is the *external sphincter*, consisting of striped muscle fibers. At the uppermost part, striped and

unstriped fibers are mingled; lower down the striped fibers alone exist, and become more numerous. They form a muscular bridge across the front of the urethra, but do not surround it; only at the apex of the prostate do they form a circular muscle, completely surrounding the canal at the level of the pelvic diaphragm, with whose fibers they are closely interwoven.

Blood-vessels of the Prostate.—The arteries are small, and are derived from the inferior vesical and the middle hemorrhoidal. The veins are large and numerous, even in the gland itself. They leave the prostate on either side, and form in conjunction with the veins of the bladder and of the seminal vesicles the vesico-prostatic plexus of veins. The lymph vessels are numerous; they form a meshwork on the surface of the prostate, unite into two trunks on either side, and empty into the most anterior of the pelvic lymph nodes. The nerves are derived from the hypogastric plexus.

Variations in the Prostate, According to Age.—The development of the prostate and seminal vesicles proceeds hand in hand with that of the testicles. During infancy they are small; at puberty they grow rapidly, and reach their full development when the individual arrives at manhood. The muscles of the gland are fully developed early, the glandular tissue not until puberty. In advanced age spherical concretions are often formed in the ducts of the prostate; they may reach a considerable size, so that they may be felt during the passage of a metal instrument by a finger in the rectum. They may cast a shadow on an X-ray plate.

Deformities of the Prostate.—Congenital defects of the prostate are rare. Absence of the prostate is only observed in conjunction with marked defects of other portions of the genito-urinary apparatus. The *ejaculatory ducts* may open in an abnormal situation. They may unite into a single canal, or one or both may open in the floor of the sinus pocularis. In Cruveilhier's case they united in a single canal, which opened on the dorsum of the penis just behind the glands. The sinus pocularis may have so large an opening as to engage the tip of a sound or catheter. The opening may be wanting and the cystlike formation produced may cause temporary retention of urine in newborn male infants.

Functions of the Prostate.—The muscles of the prostate act as vesical sphincters, and also to express the secretion of the prostate itself into the urethra. Further, they open the ejaculatory ducts and permit the escape of semen into the prostatic urethra, as well as propel it into the bulbous portion. During sexual excitement the verumontanum is supposed to swell and prevent regurgitation of semen into the bladder (denied by certain observers—Walker). The seat of sensation during coitus is in the prostatic urethra or in the verumontanum, or both. The glandular function of the prostate appears to be not only to dilute the semen, but also to render the movements of the spermatozoa more active. They are said to be immobile in the testis and seminal vesicle, whereas, after dilution with prostatic fluid, they remain alive and motile under suitable conditions for many hours. (See Semen.)

The Secretion of the Prostate.—The secretion of the prostate is a nonviscid, watery, turbid fluid, faintly acid or neutral in reaction, rarely alkaline. Its odor is that of semen, and is supposed to be due to lecithin. Under the microscope, cubical and pyramidal epithelia and clumps of lecithin granules may be seen, and in some instances the so-called amyloid bodies or sympexions. Under normal conditions pus cells and spermatozoa are absent. If some of the secretion be placed under the microscope and a drop of a one-per-cent solution of ammonium phosphate be added, the so-called Böttcher's crystals are precipitated. They are rather slender, pointed crystals, arranged in stars or crossed in pairs like a saw-buck, and are found only in prostatic secretion (Fürbringer). In pathological states, notably in seminal vesiculitis, they are often found ready formed on examining the expressed secretion. They may also be found in the semen of men rendered sterile by double epididymitis.

Methods of Examining the Prostate.—The prostate may be examined in a variety of ways, as follows: (1) Rectal palpation. (2) Urethral examination. (3) Combined rectal and urethral examination. (4) Cystoscopy and endoscopy.

1. Rectal Palpation.—The bladder should contain a moderate quantity of urine—i. e., be neither distended nor empty. The patient is placed in the knee-chest position on a table or bed, or may stand leaning over the back of a chair, one knee resting on the chair and the thighs separated. With the patient on his back the examination is not so satisfactory. The right forefinger of the surgeon, protected by a rubber glove or a thin rubber finger cot, is lubricated and gently introduced into the anus with a slight boring motion. After passing the sphincter the finger comes in contact with the membranous urethra on the anterior rectal wall for about half an inch, then with the prostate. Normally the prostate is felt as a slightly prominent, heart-shaped body, an inch and a half long, of firm, elastic consistence. By palpation one determines general or one-sided enlargement, the presence of nodules, or of general or localized changes in consistence, as induration, fluctuation; also the presence of tenderness. Bimanual palpation of the prostate is seldom useful except in very slender subjects.

2. Urethral Examination with a Metal Catheter.—If a silver catheter of medium curvature be introduced into the urethra, and it is found necessary to depress the shaft of the instrument nearly to the horizontal before urine flows, we may conclude that the prostatic urethra is notably increased in length and that the prostate gland is correspondingly increased in size.

A maneuver, described by Socin, for the determination of the length of the prostatic urethra is thus performed. A silk or other catheter is introduced into the bladder until urine flows. The catheter is then withdrawn until the flow ceases—i. e., the lateral eye of the catheter is inclosed within the prostate. The length of the catheter protruding from the penis is then measured. The

surgeon then introduces his finger into the rectum while an assistant holds the penis in an unchanging position; with his left hand the surgeon withdraws the catheter until he feels its tip emerge from the prostate into the membranous urethra. The length of the protruding catheter is again measured. The difference between the two measurements, less the beak of the instrument beyond the eye, is approximately the length of the prostatic urethra. When the prostatic urethra is considerably increased in length, it indicates an hypertrophy of the middle lobe or the formation of a marked prostatic bar. The length of the entire urethra in healthy male adults varies a good deal, according to the length of the penis. It may be from 16 to 22 cm., on the average about 18 cm.—a little less than 7 inches. (See also Urethra.) Usually the length of catheter introduced into the urethra before urine begins to flow is from 7½ to 8¼ inches (19 to 21 cm.). Any marked increase over this distance indicates prostatic enlargement. That enlargements or irregularities of the base of the prostate may be appreciated with the searcher has been mentioned under Methods of Examining the Bladder.

3. Combined Rectal and Urethral Examination.—It is sometimes of advantage to introduce a metal instrument, size 24 to 28 French, and to palpate the prostate *per rectum* at the same time.

4. Endoscopy and Cystoscopy.—It is possible, and not very difficult, to introduce a straight endoscopic tube into the prostatic urethra, and to study the condition of its mucous membrane with more or less success. The verumontanum can be recognized, but not the sinus pocularis unless it is the seat of disease, when its orifice may gape or permit the observer to see a purulent or muco-purulent discharge escaping from it. The method is impossible in marked prostatic hypertrophy. It is quite painful, but has been rather extensively used in America during recent years.

The retrospective *cystoscope* permits a thorough examination of the bladder face of the prostate, and will disclose the presence of a bar, a collar, or an enlarged middle lobe. It is important in this connection to bear in mind that in the cystoscopic field an enlarged or pedunculated middle lobe appears much larger than it really is. The surgeon might thus conclude that a suprapubic cut was necessary for its removal, whereas a perineal cut might answer every purpose, in the opinion of many surgeons, including myself, a better operation when practicable.

In cases of prostatic hypertrophy, with unequal enlargement of the lobes or with a greatly increased urethral distance, the use of the cystoscope is not practicable, even under a general anesthetic, without undue violence. If the kidneys are faulty there is also risk of uremia. In elderly men, therefore, the use of the cystoscope should be preceded by an examination of the urine, with particular regard to the function of the kidneys, and by rectal palpation of the prostate. In acute inflammations of the prostate, in acute posterior urethritis, and in cases where malignant disease of the prostate is suspected, the use of the cystoscope is contraindicated.

INJURIES OF THE PROSTATE

On account of its protected position, wounds of the prostate from accidental violence are rare. Even the most severe contusions of the perineum do not injure the prostate. Some cases of impalement involve the prostate, its injury being usually of secondary consequence. Gunshot wounds of the prostate are not frequent. During the Civil War, only 8 cases of injury of the prostate were recorded among 3,174 gunshot wounds of the pelvic organs (Otis).

In perineal operations, such as perineal cystotomy for the extraction of stone, the prostate may be cut or lacerated. Injuries of the prostate during catheterization, owing to rough or careless manipulations or to the use of instruments with an improper curve, are not infrequent. They are usually well borne unless the prostate is the seat of infection, or unless the instrument penetrates the outer fibrous capsule inclosing the gland and opens up the connective-tissue planes of the pelvis. In the former case abscess of the prostate may occur, in the latter septic cellulitis of the pelvic connective tissue or fatal purulent peritonitis. When the prostate is wounded during catheterization, there will be bleeding from the meatus and bloody urine. In open wounds of the prostate the bladder is often injured. In such cases infiltration of urine must be prevented by perineal drainage of the bladder and suture of the wound in the bladder wall, if it be accessible.

DISEASES OF THE PROSTATE

The inflammations of the prostate gland may be either acute or chronic.

Acute Prostatitis.—By far the commonest cause of acute inflammation of the prostate is the extension of a gonorrheal urethritis to the prostatic urethra, and thence into the substance of the organ. The gonorrhea may be acute or chronic; the infection may be due to the gonococcus alone, or there may be a mixed infection with other pyogenic microbes. Infection usually follows the prostatic ducts, or may occur through injuries of the mucous membrane due to instrumentation during acute posterior urethritis. Alexander lays much stress upon the frequent occurrence of prostatitis as the result of irrigations of the anterior urethra during acute gonorrhea. My own experience is at variance with this view. I have seen as many instances of acute prostatitis in cases where no irrigations had been used, as in those subjected to active local treatment.

Other causes of acute prostatitis are vesical and prostatic calculi, ulcerating tumors of the bladder, the cystitis of prostatic hypertrophy, vesical tuberculosis, trauma from the passage of dirty instruments into the bladder or of clean instruments in the presence of anterior urethritis. Sexual excess, masturbation, contusions of the perineum, or the irritation produced by horseback or bicycle riding, may produce a catarrhal posterior urethritis, even hyperemia of the prostate; that they are ever the sole exciting causes of prostatic abscess

appears to me doubtful. I have never seen prostatic abscess except as the result of gonorrhea, tuberculosis, or as a complication of the cystitis of senile hypertrophy or of the cystitis due to insufficiency of the bladder from other causes. The impression that acute prostatitis, or even prostatic abscess, may be caused by apparently trifling conditions depends upon the fact that a very chronic or latent posterior urethritis of gonorrheal origin may be lighted up into an acute inflammation very easily. The gonorrhea may antedate the prostatic infection many years; the patient may believe himself well. A night spent in alcoholic and sexual debauchery, a long horseback or bicycle ride, may be followed at once by a rekindling of the chronic process and an acute prostatitis.

Prostatic abscess occurs, though rarely, as a complication of the acute exanthemata, variola, scarlatina, measles, etc.; the infection in these cases is presumably hematogenous.

Pathological Lesions.—Acute infection of the prostate may involve the glandular tissue merely, or the muscular substance, or both. In the first case three results are possible: (1) The inflammation may run a short course, ending in resolution and complete recovery. (2) The acute symptoms may subside, leaving behind a chronic inflammation of the glandular follicles. (3) The process ends in suppuration; small abscesses are formed in several glandular follicles; these rapidly grow and coalesce, forming an abscess which involves one or both sides of the prostate, and included within its fibrous capsule. Such an abscess may rupture into the urethra, the rectum, the ischio-rectal fossa or perineum, the bladder, the connective-tissue planes of the pelvis (space of Retzius), or even into the peritoneal cavity, with fatal results. In a large proportion of cases the rupture occurs into the urethra. Rare avenues are the obturator foramen, along the posterior sheath of the rectus, through the inguinal canal.

In the cases involving both muscular and glandular substance the conditions are more grave. Diffuse suppuration of the entire gland may result. Rupture into the urethra or rectum is the most favorable outcome. In other cases a diffuse necrotic inflammation of the pelvic connective tissues, purulent peritonitis, septic thrombosis of the prostatic plexus of veins, septicemia, or pyemia may end life. In some cases thrombosis of the veins of the bladder occurs, and phlegmonous pericystitis. A painful, tender tumor is then formed behind the pubes, extending a greater or less distance toward the umbilicus, together with profound septic symptoms, dysuria, and retention. The outcome of these conditions depends upon the intensity of the septic poisoning, and upon whether the process remains localized and is opened or breaks in a favorable situation or becomes diffuse. In the cases which do not die, fistulous tracts often remain in the perineum, or communicate with the rectum or with the urethra, or both. In the cases of pericystitis a contracted cicatricial bladder remains. (See Bladder.)

Symptoms and Diagnosis of Acute Prostatitis.—*Acute Gonorrheal Prostatitis.*—In these cases the symptoms of acute posterior urethritis will have

preceded the prostatic involvement for days or weeks. If the prostate becomes involved in the course of a chronic posterior urethritis, there will be a history of an old uncured gonorrhea with acute exacerbations. In this latter group the exciting cause may be prolonged sexual excitement, coitus, acute alcoholism, overfatigue, the passage of a sound, or other source of local irritation. (See also Gonorrhea.) The involvement of the prostate is indicated in severe cases by a chill, a rise of temperature, and a rapid pulse, prostration, and other septic symptoms. Such an onset usually indicates that the process will end in suppuration. Alexander states, from his own experience, that in cases of prostatic abscess the original septic symptoms, including fever, often subside in a few days, though the abscess is still developing. The general symptoms of constitutional depression are usually marked. In several cases I have observed great mental depression, amounting almost to acute melancholia. Locally, the patient will complain of increased frequency of urination, of a sense of weight and fullness in the rectum and perineum, of pain in the sacral region. Defecation is painful, and the sensation of a large foreign body in the rectum is present. Urination becomes more and more frequent, painful, and difficult. If an abscess forms, retention of urine is the rule. The passage of a catheter is difficult and very painful. Rectal palpation reveals the prostate much enlarged, tender, hot, and throbbing, and either hard and elastic or, if an abscess has approached the rectal surface, boggy or actually fluctuating. The abscess may be confined to a single lobe, or involve both sides of the gland. If not opened, the abscess ruptures into the urethra, the ischiorectal fossa, or burrows along the urethra and perineum, or into the rectum, rarely into the bladder. Perforation into the connective-tissue planes of the pelvis or into the peritoneal cavity is fortunately rare. Rupture into the urethra may occur during the straining efforts to urinate, or as the result of passing a catheter for the relief of retention. This will be indicated by the discharge of considerable pus with the urine, sometimes also from the meatus independent of urination. Rupture of the abscess is followed by marked relief from the symptoms. By rectal massage, pus in quantity may sometimes be pressed out of the abscess cavity, and made to appear at the meatus. If the opening is small, it may close or drain imperfectly. In this event septic and painful symptoms may recur, sometimes with the formation of new and more serious lesions; and as long as the abscess cavity remains unhealed and in communication with the urethra, there is always danger of renewed infection. A certain proportion go on to spontaneous healing. The abscess may rupture into the rectum. In these cases gas and feces may enter the urethra and appear in the urine, or the urine may enter the rectum at each urination. In some cases an opening will form into the rectum, and also perforate the perineum. I had one patient who, as the result of a prostatic abscess, continued for many months to pass gas through a small perineal fistula. Cure occurred in this case without operation on the fistula. I have another patient who has at intervals, for years, passed gas and feces *per urethram*. The fistula closes at times and again breaks down.

The occurrence of pronounced septic symptoms and complete retention of urine is an indication for operative interference by a perineal incision, even though fluctuation is doubtful or inappreciable on rectal palpation. Prostatectomy is indicated in many cases.

In the cases of acute prostatitis which do not end in suppuration the symptoms are similar in character, though less severe. Chills and pronounced septic symptoms are usually absent. Retention of urine is transient or does not occur. Under rest and suitable treatment the swollen prostate regains its normal condition in a few weeks. In other cases the disease becomes chronic.

Chronic Prostatitis.—The course of chronic prostatitis following abscess of the prostate is sometimes such as has already been indicated—namely, the continued presence of sinuses or the occurrence of acute attacks of inflammation, sometimes causing the patient merely more or less marked urinary discomfort, sometimes ending in the formation of an abscess requiring incision. In some cases the continuance of the symptoms is due to the presence of small, unhealed abscesses in the substance of the gland, with occasional retention of pus. Many of these cases are diagnosticated as cases of relapsing posterior urethritis. The patients suffer from frequent urination, pyuria, from perineal pain and discomfort. They often have a chronic urethral discharge. The surgeon will bear in mind that when a prostatic abscess ruptures into the urethra, spontaneous cure may or may not occur. Unless the symptoms rapidly subside, a perineal incision and proper drainage is necessary. Under such circumstances we often find smaller or larger abscess cavities in the gland, separated by trabeculæ of more or less infiltrated prostatic tissue, the condition being quite unfavorable for spontaneous cure.

Chronic Cicatricial Prostatitis the Result of Prostatic Suppuration.—In some cases of suppurative inflammation of the prostate, nature affects a cure of a certain kind. The suppurative lesion is healed at the expense of more or less complete destruction of the glandular substance and the production of firm scar tissue. On palpation these prostates feel small, hard, and often nodular. These patients suffer from symptoms which vary somewhat in different cases. In some no symptoms at all are observed; in others the patients complain of difficult urination; the stream is hard to start, and is expelled with but little force; there may in a few cases be dribbling of urine or an insufficient bladder. In others the symptoms are those of chronic posterior urethritis. A decided disturbance of the psychic sphere may be present. These patients are neurasthenic, often hypochondriacal. They may become prematurely impotent. (See also Impotence.) The only treatment seems to be a perineal section, division with a knife of the cicatricial prostatic ring, and the subsequent passage of large sounds. This condition may be differentiated from senile atrophy of the prostate, since it occurs in young or middle-aged, not in elderly men.

Chronic Follicular Prostatitis, Parenchymatous Prostatitis.—In certain cases of acute gonorrheal prostatitis the symptoms subside without sup-

puration, but the patient is left with a chronic posterior urethritis and a more or less extensive infection of the ducts and glandular follicles of the prostate. Such cases have often been complicated by epididymitis and infection of the seminal vesicles. Posterior urethritis is present in all cases. In some of these the infection of the prostate gives neither definite signs nor symptoms, and passes unrecognized. The symptoms are those of an intractable posterior urethritis, and often of a coexistent seminal vesiculitis *with recurrent attacks of epididymitis.* Rectal palpation may reveal nothing abnormal about the prostate except a little tenderness. In other cases the patients will suffer from pain and tenderness in the perineum, from recurring attacks of acute prostatitis and posterior urethritis. In these rectal examination will reveal a prostate larger than normal, and more or less tender. Expression of the prostatic secretion will show a greater or less admixture of pus.

The *subjective symptoms* vary in different cases. If the prostate is much enlarged they will have a feeling as though a foreign body was in the rectum, together with moderate rectal pain and tenesmus. They will have, in addition, the signs and symptoms of chronic posterior urethritis. (See Gonorrhea.) The symptom-complex is thus often due to several coexisting lesions—namely, prostatitis, posterior urethritis, seminal vesiculitis, and recurrent attacks of epididymitis. There is often disturbance of the sexual functions, nocturnal pollutions, frequent erections, usually with premature ejaculation, later on partial or complete impotence, with or without absence of sexual desire. Changes in the semen are observed. (See Pathological Changes in the Semen.) Nearly all these patients suffer from fairly marked psychical disturbances. They become neurasthenic, hypochondriacal, and mentally depressed. The prognosis of this form of chronic prostatitis is not very favorable. These unfortunates continue to suffer indefinitely, and are not greatly benefited by treatment.

Prostatorrhea.—Prostatorrhea is hardly to be regarded as a disease, though often associated with chronic inflammation of the seminal vesicles. When existing alone, the symptoms consist of a discharge from the urethra of normal prostatic secretion. (See Functions of the Prostate.) The discharge occurs after urination, during straining at stool, or at other times. The quantity of discharge is usually small—merely a drop or two of milky fluid. In rare cases it may be larger, and may amount to a drachm or two in twenty-four hours. The patients are nearly all neurotic or neurasthenic individuals, frequently masturbators or sexual perverts. They usually believe that they are suffering from seminal losses (spermatorrhea), and are much disquieted thereby. The condition is sometimes attributed to sexual excesses. That it ever follows normal coitus, however frequent, in an otherwise healthy individual, appears to me doubtful.

Tuberculosis of the Prostate.—Tuberculosis of the prostate may be (1) primary in the gland itself; (2) secondary to tuberculosis in distant organs—namely, the lungs, the peritoneum, etc.; (3) the infection is secondary to

tuberculosis of other portions of the genito-urinary tract. In the primary cases the infection may be tuberculous from the start, or may be ingrafted upon a chronic gonorrheal prostatitis. The third group forms the most common type, the prostatic invasion being secondary to tuberculosis of the epididymis or of the kidney, the former being more common.

Occurrence.—As in other forms of tuberculosis, young adults with an hereditary or acquired tuberculous predisposition are most often affected.

Pathological Lesions.—In the primary cases the lesions of the prostate are the most pronounced. In the cases complicating tuberculosis of the lungs or peritoneum, death usually occurs before the prostatic lesion is far advanced. Hence, in these the condition of the prostate is of only secondary importance. Tuberculous lesions of the prostate consist in the formation of nodules of tuberculous granulation tissue, which undergo the regular changes observed in tubercle—namely, caseation, softening, the formation of tuberculous abscesses and fistulæ, often followed here by secondary infection with pyogenic organisms. In some cases the caseous material is replaced by calcareous deposits and cicatrization; even spontaneous cure is possible. The infection is usually at first unilateral, so that when both sides of the prostate are involved the lesion is older and more marked on one side than on the other. This is notably true when the prostatic infection is secondary to a unilateral tuberculous epididymitis. When the infection takes place just beneath the mucous membrane of the prostatic urethra, early ulceration produces very marked symptoms, and usually abundant bacilli in the urine, so that an early diagnosis is easy in these cases. When central tuberculous nodules break down they may perforate in any of the directions mentioned under Prostatic Abscess—i. e., into the urethra, perineum, rectum, etc. Though extremely slow in their progress, these prostatic abscesses, when once they have perforated into the urethra or rectum, speedily become a source of imminent danger from urinary infiltration and mixed infection with pus cocci.

Symptoms and Diagnosis.—In the group of cases in which the tuberculous infection is ingrafted upon a chronic gonorrheal posterior urethritis, the invasion with tubercle is not, as a rule, attended by any sudden change of symptoms. The patient gradually gets worse in spite of treatment, and examination of the prostate discloses a nodular enlargement, usually of one lateral lobe. In other cases bleeding from the prostatic urethra may first attract the surgeon's attention to the probability of a tuberculous infection. In the cases not preceded by gonorrhea the patient usually presents himself, suffering from a chronic posterior urethritis for which there is no apparent cause. Gradually the signs and symptoms of a tuberculous lesion are developed.

In that group secondary to phthisis or tuberculosis of the peritoneum the symptoms of vesical irritation, with pyuria, sometimes hematuria, are gradually developed, usually when the patient's general condition is already quite hopeless.

In the group of cases secondary to tuberculous epididymitis the presence

of an enlarged, nodular, hard, usually painless epididymis upon one side is followed or accompanied by vesical irritation, the appearance of pus and shreds in the urine, sometimes hematuria. Rectal examination discloses a nodular prostate.

The following are the data upon which the *diagnosis* may be based: A tuberculous personal or family history. The presence of other tuberculous lesions, either distant or of other parts of the genito-urinary apparatus, notably of the epididymis. The extreme chronicity of the disease. The presence of tubercle bacilli in the urine. The utter futility of ordinarily successful treatment. *The fact that such treatment only aggravates the symptoms.* The introduction of a sound or catheter and irrigation of the bladder is followed by an exacerbation of all the symptoms, by increased pain and frequency, a hemorrhage, an attack of epididymitis, etc. The irregular nodular enlargement of one or both lobes of the prostate. The formation of a tuberculous abscess or the existence of a tuberculous fistula as the result of such an abscess. The occurrence of one or more sharp attacks of prostatic bleeding. These are the data whereby we arrive at the diagnosis of tuberculosis of the prostate.

Prognosis.—The prognosis of prostatic tuberculosis is bad, though the course of the disease is very slow. Death comes from dissemination of tubercle, from exhaustion, from abscess formation with septic infection or urinary infiltration, from kidney tuberculosis, or from preëxistent tuberculous lesions of the lungs. By hygienic measures, life out of doors in a suitable climate, etc., cures are possible in a few cases. A few operative cures have been reported from incision and curettement of tuberculous prostatic abscesses.

Prostatic Calculi.—Prostatic stones may originate from one of two sources: (1) From concretions formed in the prostatic ducts; (2) from ordinary vesical calculi which become impacted in the prostatic portion of the urethra. Such calculi may originally lodge in such a manner that a portion of the stone projects into the bladder. The continued growth by deposition of phosphates may cause such stones to become firmly fixed, so that a cutting operation may be necessary for their removal.

Prostatic calculi originating in the *prostatic ducts* (corpora amylacea) are quite common in elderly men, though they rarely grow to a size larger than that of a pea, and seldom give rise to any symptoms. I have repeatedly detected them in the prostates of old men by means of X-ray pictures, since they usually contain enough phosphates to cast a definite shadow. When these concretions are multiple, they may cause atrophy of the prostatic substance, so that a considerable cavity is formed, containing numerous small stones, readily palpated *per rectum*, a grating sensation being imparted to the examining finger. When such calculi enter and remain in the prostatic urethra they produce the same symptoms as ordinary calculi in the same situation.

Symptoms and Diagnosis.—The symptoms produced by prostatic calculi may be simply those of chronic prostatitis. They may cause prostatic abscess or urinary obstruction, or in many cases the symptoms of vesical calculus.

The diagnosis is to be made by the searcher, by rectal palpation, and by X-ray examination.

Hypertrophy of the Prostate—Adeno-fibroma of the Prostate.—During advanced life, between the ages of fifty and seventy years, the most important and commonest disease of the prostate is the so-called senile enlargement or hypertrophy.

Occurrence.—A large proportion of all old men have enlarged prostates. Such is the case among seventy-five per cent of men sixty years old. Only about fifteen per cent, however, suffer inconvenience therefrom. Symptoms develop rarely before forty-five or after seventy years, usually between fifty and sixty.

Causation.—Many theories have been formulated to account for prostatic enlargement. None of them, so far as I am aware, have stood the test of careful investigation. Among such may be mentioned arterio-sclerosis (Guyon); analogy to fibro-myoma of the uterus (Velpeau, Thompson); sexual senility (White and Martin); chronic congestion, due to a sedentary mode of life, to sexual excess, to continence, to improper modes of coitus—i. e., coitus reservatus, interruptus, etc.—to chronic gonorrheal posterior urethritis.

Lesions.—The lesions consist of a hyperplasia of the glandular and muscular elements of the prostate. This may involve both structures equally or be confined chiefly to either the glandular or muscular substance. In addition there is an interstitial inflammation with an increase of fibrous tissue, with, from time to time, acute inflammatory attacks. If the glandular hyperplasia is excessive the tumor will be soft. If muscle and fibrous tissue are notably increased the gland will be hard. Between these two extremes there are gradations. The enlargement may be symmetrical; it may be confined chiefly to one lateral lobe, more rarely to the median lobe. In exceptional cases a nodular, sharply circumscribed glandular tumor may be formed. In the cases involving merely the median lobe the hypertrophy is largely muscular and fibrous; glandular elements are few in this portion of the organ. There may thus be formed a rounded, sessile, or pedunculated tumor, projecting into the bladder at the urethral orifice, causing obstruction to urination. Such a projecting middle lobe may reach a considerable size, and form a pedunculated, movable tumor within the bladder as large as a hen's egg. It may act like a ball valve, so that the more violent the muscular effort of the individual to empty the bladder the more firmly is the tumor pressed against the urethral orifice. Absolute retention is frequent in such cases. In some cases of general hypertrophy the deformity consists in the formation of a rounded, semicircular, projecting shelf, or of a complete collar around the urethral orifice, or of a bilateral projection on either side of the orifice so that its shape is changed to an irregular slit. In all these cases intravesical pressure merely serves to close the urethra more tightly. More frequent than these intravesical enlargements are hypertrophies of the lateral lobes. These form a readily palpable tumor projecting into the rectum. One lobe may be larger than the other, but in

the average case rectal palpation finds a prominent, rounded mass, of elastic or firm consistence, as large, merely, as a greengage plum, or in some cases as large as a good-sized apple, so that the finger is unable to reach its upper border. The small prostates giving symptoms are apt to be hard; the larger ones more soft and elastic, indicating an excess of fibrous tissue or the formation of adenomatous masses respectively. In some cases a median furrow can be felt, and a notch in the upper border of the organ indicating that the isthmus is not involved.

Lengthening and Distortion of the Prostatic Urethra.—In all cases of prostatic hypertrophy the curve of the prostatic urethra is changed to one of greater radius. In hypertrophy of the lateral lobes the caliber of the canal is dilated and changed in shape from a transverse slit to a vertical one, whose height increases with the growth of the lateral lobes. In cases of unequal hypertrophy, one lobe may encroach upon the other, and thus render the urethra tortuous. The practical bearing of the increased radius of the prostatic curve is that rigid instruments which pass readily through the normal prostate cannot be passed through the deformed canal. Instruments of much wider curve must be used (see Fig. 203). The instrument which I have found most useful in these cases

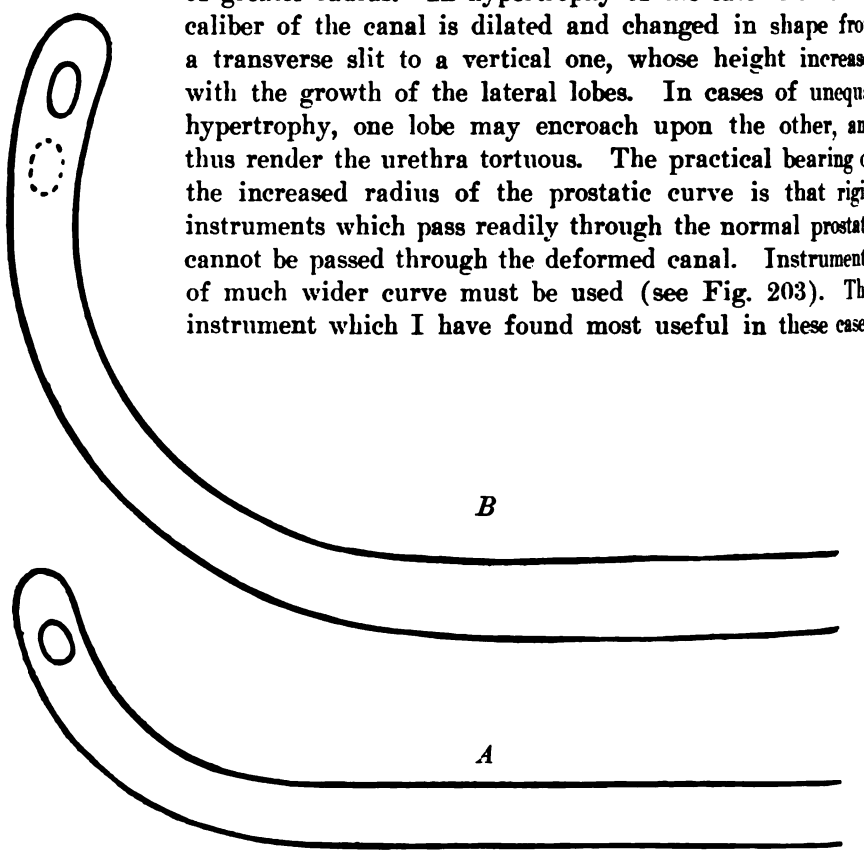


Fig. 203.—*A*. Outline of silver catheter having normal curve.
B. Outline of catheter with prostatic curve.

is shown in the cut. It is a silver catheter with the prostatic curve indicated, and a long shaft; size, 25 French. The model was furnished to me by Dr. Charles McBurney.

In those cases producing an intravesical projection the urethral orifice ceases to be the lowest point of the bladder on account of the projecting mass of

prostatic tissue around it, and in these latter especially, the length of the prostatic urethra is markedly increased, in some cases as much as 5 cm. It is somewhat increased in all, but not greatly except in the class mentioned. (See also Anatomy of the Prostate.)

An important fact to bear in mind when selecting an instrument for use in prostatic hypertrophy is that the roof of the urethra remains practically unaltered, so that an instrument whose beak hugs the roof of the canal will be less apt to meet with mechanical obstruction. Hence the value of the elbowed catheter (catheter coudé of Mercier), the beak of which turns sharply upward (see Fig. 204). This catheter is useful under all conditions. In cases with a dilated bulbous portion it will not catch on the edge of the triangular ligament, and in my experience passes more readily than any other form of instrument. In the Mercier catheter the beak makes an angle of one hundred and ten degrees with the shaft; in that of Leroy, an angle of one hundred and thirty degrees. In some cases the double-elbowed catheter of Mercier is useful (see Fig. 205). A valuable procedure was devised by Hey in 1814. A stiff English catheter containing its stylet is bent into an exaggerated prostatic curve (see Fig. 208). It is allowed to remain thus bent for several days. When wanted for use the stylet is bent to a normal, or ordinary prostatic, curve, and the instrument introduced until it meets with resistance in the prostate. The

FIG. 204.—THE CATHETER COUDÉ OF MERCIER.
(Watson and Cunningham.)

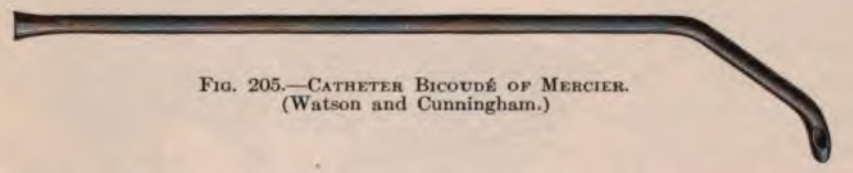


FIG. 205.—CATHETER BICOUDÉ OF MERCIER.
(Watson and Cunningham.)

stylet is then withdrawn about two inches, and the catheter at the same time is pushed onward. When freed from the stylet the catheter tends to resume its exaggerated curve, and thus rides sharply upward and forward, often passing by the obstruction into the bladder. This maneuver is especially useful in the cases where an actual angulation of the floor of the urethra exists, caused by the sharp prominence of an hypertrophied isthmus or middle lobe (see Figs. 206 and 207). In order to reach the bladder the instrument must pass upward and forward.

As noted under examination of the bladder, the enlargement of the prostatic urethra may be so marked in cases of great hypertrophy of the lateral lobes that a considerable cavity exists, such that a searcher can be moved about quite freely therein. The examiner may thus be deceived as to the position of the instrument and believe that it is in the bladder.

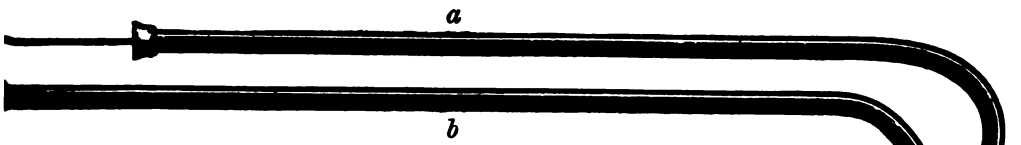
Changes in the Bladder as the Result of Prostatic Hypertrophy.—Owing to the constant straining during urination, eccentric hypertrophy, trabeculation of the bladder wall, and sometimes the formation of diverticula result. (See Cystitis and Eccentric Hypertrophy of Bladder.) As the result of attacks of retention with extreme distention of the bladder, atony of the bladder may result. Partly on this account and partly on the account of the formation of a postprostatic pouch, the bladder becomes insufficient, and always contains after urination a certain quantity of residual urine. In these cases not only is the muscular tone of the bladder lost, but also actual degeneration of the muscle occurs. The conditions are then ideal for infection and the production of cystitis. With the attacks of retention there is intense congestion of the prostatic plexus of veins, with acute swelling of the prostate, and sometimes sharp hemorrhage into the urethra. The changes produced in the ureters and kidney as the result of prostatic obstruction are described under Surgical Diseases of the Kidney and Ureter. Briefly, the sequence of events is residual urine, catheter infection, cystitis, ureteritis, pyelonephritis, and death.

Fig. 206.—Sagittal Section of Generalized Hypertrophy of the Prostate, Showing Sharp Angulation of the Prostatic Urethra and Intravesical Projection of the Middle Lobe.

Fig. 207.—Generalized Irregular Hypertrophy of the Prostate. The intravesical projection has produced a Y-shaped division of the prostatic urethra.

Symptoms of Prostatic Hypertrophy.—The three most prominent symptoms of enlarged prostate are frequent urination, difficult urination including retention, and dribbling of urine.

Frequent Urination.—Usually the first symptom to attract the attention f an elderly man to his urinary apparatus is increased frequency of urination. *he frequency is nearly always most marked during the night and in the early orning hours.* At first this nocturnal frequency may be the only symptom oted; during the day the intervals may be normal, or nearly so. Polyuria is ften more or less marked in prostatics; sometimes it is a part of the symptom-omplex of interstitial nephritis with arteriosclerosis and an hypertrophied left entricle. In some cases it is believed by certain observers that it is merely a reflex phenomenon due to the irritation of a congested prostate. Gradually he necessity to get up at night will become a serious annoyance. The first part f the night may be passed in sleep, but toward morning the frequent desire o urinate will make rest impossible. In some cases an early symptom caused y prostatic congestion is a marked *libido sexualis*, with frequent and annoying orning erections, amounting in some cases almost to priapism. This may cur in old men who have ceased to lead an active sexual life for years.



. 208.—Hey's Method of Introducing a Catheter in Cases of Prostatic Hypertrophy, with Angulation of the Prostatic Urethra Due to an Enlarged Median Lobe. *a*. Exaggerated curve of the same after the stylet has been withdrawn. *b*. Elastic catheter containing a stylet.

Difficult Urination.—In all cases of prostatic obstruction, difficult urination **an early** symptom. The stream is hard to start; sometimes the patient must **nd for** several minutes before the flow begins, meanwhile straining and **nipulating** his penis, and changing his position, bending forward, etc. The **ream is feeble**, small, and without propulsive force, so that, if careless, the **dividual** will wet his shoes and trousers. The time necessary to complete **e act is prolonged**, and at the end there is no sharp *coup de piston*. The **ream decreases** to feeble spurts, and ends by dribbling, which continues for **everal minutes**, so that the under-garments are wet with urine. No sensation **f satisfaction** follows urination; many patients are quite conscious that they **ave failed to completely empty the bladder**. A peculiar and characteristic **ymptom is that the more the patient strains the less successful he is, for rea-ons already explained.** As time goes on, and the obstruction grows more **arked, urination is accomplished almost by drops, until from some trifling use, such as exposure to cold and wet, notably wetting of the feet, a little erindulgence in alcohol, a heavy dinner, or sexual excitement, etc., absolute tention occurs.** The amount of pain felt during urination varies with the egree of congestion or of inflammation of the prostate and bladder. (See elow.)

Dribbling of Urine.—One of the most annoying symptoms of prostatic hy-ertrophy is constant dribbling of urine. It does not occur in all cases, nor

is it always due to the same cause. Dribbling occurs when the patient has complete retention. The greatly distended bladder simply overflows constantly, the escape amounting to about the quantity furnished by the kidneys. The bladder always remains full (ischuria paradoxa). One would suppose that the condition was scarcely to be confounded with any other, since the distended bladder always forms a tumor recognizable by ordinary methods of examination; and yet it is extraordinary how often these patients are thought to be suffering from true incontinence, or, in the early stages, before dribbling occurs, from suppression of urine. In some cases, though the bladder is nearly or quite sufficient, spasmodic contraction of the detrusor muscle occurs involuntarily every few minutes, so that in spite of himself the patient voids a little urine. This is an expression of an intense irritability of the prostatic urethra and trigone, due to congestion.

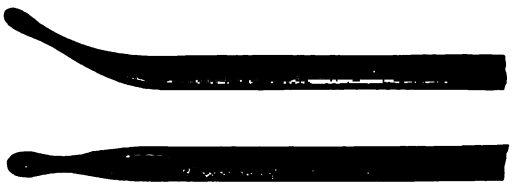


FIG. 209.—BOUGIE CATHETERS, SOMETIMES USEFUL IN PROSTATIC OBSTRUCTION. (Watson and Cunningham.)

True incontinence is rarely seen in prostatics. It occurs only in those cases where the deformity of the lateral lobes is such that the sphincters are unable to close the urethral orifice. No enlarged median lobe, prostatic collar, or bar exists in these cases; the urine simply dribbles away as fast as it enters the bladder.

COURSE OF THE DISEASE.—The progress of prostatic enlargement is sometimes divided into three stages: (1) The stage of congestion, with a sufficient bladder. (2) The stage of partial retention—i. e., insufficient bladder with residual urine. (3) The stage of complete retention. A more practical distinction may be made by dividing the condition into two stages—namely, the aseptic stage and the stage of infection; for, though cystitis and ascending infection to the kidneys are usually regarded as complications, they occur so regularly, and even inevitably, sometimes early, sometimes late in the disease, and are such a distinct source of suffering and peril to the individual, that the moment when the bladder becomes infected sharply marks a condition of mere discomfort from one of extreme gravity.

During the period before infection occurs the symptoms of obstruction gradually increase in severity. In some cases they may be much alleviated by regular aseptic catheterization; in other cases the bladder is intolerant of instrumentation. The passage of an instrument is followed by sharp bleeding from the prostate, or by chills and urinary fever. In other cases, catheterization done under the most careful aseptic precautions results speedily in bladder infection, posterior urethritis, acute prostatitis, epididymitis, rarely prostatic abscess.

If no treatment is instituted, sooner or later, with or without an exciting cause, complete retention occurs, with dribbling overflow. Under careful man-

gement the condition may leave the patient but little worse; he may even be ept fairly comfortable for years. In other cases a neglected retention may ave the patient with atony of the bladder, never completely recovered from. repetition of such attacks may end in total inability to urinate, so that all he water must be drawn with a catheter. A serious danger exists when a atient has retention and a greatly distended bladder. If the bladder is emp- ied at once, the most serious results may follow. (See Cystitis.)

'IG. 210.—HYPERTROPHY OF BOTH LATERAL AND MEDIAN LOBES OF THE PROSTATE. The Y-shape taken by the prostatic urethra as it passes on either side of the median enlargement to enter the bladder is well shown. Reduced one fifth. (After Watson.)

It is at this time that the bladder and prostatic urethra are most susceptible bacterial invasion, and in many cases the outbreak of a sharp cystitis dates rom such an occurrence. This matter is so important that I venture to repeat greater detail the caution already given elsewhere. To avoid as far as pos- ible the dangers of emptying the bladder completely when it is greatly dis- ended, a part only of the accumulated urine may be drawn off at one time.

The patient should be catheterized in the recumbent posture, and should be kept in bed. The following day the bladder may be more nearly emptied at several sittings, and after several days completely so. An alternative procedure is as follows: The bladder may be emptied by catheter at once and the urine replaced by a quantity of boric-acid solution or sterile 0.9-per-cent salt solution, equal to about one half the normal capacity of the bladder.

In some cases of prostatic hypertrophy the development of cystitis is gradual, and may cause but slight additional discomfort for a long period. Under careful treatment it may be held in check for many years. Cured in any proper sense it never is, so long as the prostatic obstruction remains.

Spontaneous infection of the bladder may occur, though doubtless it is rare. In most cases infection is due to catheterism. A posterior urethritis always coexists. As noted under Diseases of the Bladder, the cystitis of prostatic hypertrophy is always accompanied sooner or later by ammoniacal decomposition of the urine. When this occurs, the pain, frequency, and general distress become much more marked. (See Cystitis.) In other cases, notably when retention has been relieved by the catheter, the cystitis may occur as an intense hemorrhagic inflammation, attended by a chill, fever, prostration, etc. As elsewhere related, these patients may at once pass into a condition of acute sepsis. They may develop an acute pyelonephritis or uremia, or a combination of these conditions, with a rapidly fatal termination.

Complications.—Acute prostatitis, prostatic abscess, acute or subacute epididymitis, and seminal vesiculitis are among the complications of enlarged prostate with infection of the bladder and prostatic urethra.

Vesical Calculus.—An ammoniacal cystitis, with residual urine and a postprostatic pouch, furnish ideal conditions for the formation of phosphatic calculi in the bladder. Such stones may or may not produce marked symptoms of their own. Usually they do not, since they habitually rest in the postprostatic pouch, and do not come in contact with the more sensitive trigone and internal urethral orifice.

Diagnosis of Prostatic Hypertrophy.—From what has preceded it will appear that the diagnosis of enlarged prostate is usually easy. A recapitulation and a few words on differential diagnosis are here added. The mere fact that an elderly man presents himself complaining of frequent and difficult urination leads us to suspect the existence of enlarged prostate. It is rare that stricture of the urethra first develops late in life. A rectal examination will usually reveal quite plainly that the gland is enlarged. Unless there are already inflammatory complications, the prostate will not be tender. The patient is then asked to urinate in the erect posture. If there is prostatic obstruction the stream will be delayed and the urine is expelled without much force, and toward the end merely dribbles away. If he has retention, no urine will pass, or there will be more or less constant dribbling. The signs of a distended bladder will be plain. Oddly, these patients are rarely conscious of the tumor. In order to determine the degree of insufficiency and the urethral length, the patient

is then catheterized. I prefer a silk instrument with a coudé beak; if that fails to pass, a large silver catheter with a prostatic curve. The manipulations should be made with aseptic precautions and with the utmost gentleness. If the patient's urine is still clear, it is sometimes possible to keep him comfortable for years, provided there is no serious difficulty in the introduction of instruments. If cystitis already exists, the characters of the urine will be, as elsewhere, described. When the residual urine amounts to no more than two ounces, once in twenty-four hours will be often enough to use the catheter. It is best done at night, before going to bed. If four ounces of residual urine exist, the catheter must be used twice daily until improvement takes place. Larger amounts may require the use of the catheter three or four times a day. If no instrument can be passed and palliative measures fail, this being due, as a rule, to the existence of a false passage produced by some bungler, the bladder may be aspirated for a day or two above the pubes. Unless pretty rapid improvement follows, I prefer to remove the prostate after a few days, the results being usually most satisfactory.

The searcher and the cystoscope are at times useful aids in the diagnosis of enlarged prostate, notably when the middle lobe and the base of the prostate are the chief seat of enlargement. The searcher alone will usually permit us to feel knobs and irregularities of contour, and always to appreciate the post-prostatic pouch. The cystoscope may also give us valuable information when its introduction is possible. (For the differential diagnosis from cystospasm and contracture of the prostatic urethra, see these topics. For the differentiation from tumors of the prostate, see the following section.)

Tumors of the Prostate.—New growths of the prostate are rare.

Benign Tumors.—A few cases of circumscribed *fibroma* of the prostate have been reported. They form firm, smooth, sharply circumscribed tumors, usually of rounded form. They cause no general enlargement of the gland, and unless of considerable size produce no obstructive symptoms. If they lie close beneath the urethral mucous membrane they may obstruct the canal, though not palpable *per rectum*. Fuller reports such a case in a patient forty-five years of age, who had had retention for some years, apparently from prostatic obstruction. Rectal examination negative. Perineal section was made, and the finger in the prostatic urethra revealed a hard tumor the size of a robin's egg beneath the floor of the urethra. The tumor was removed and the patient regained complete control over the function of his bladder.

Cysts of the Prostate.—Minute cysts due to the closure and retention of secretion in the prostatic ducts have been observed; they are usually small, and give no symptoms. *Echinococcus* cyst of the prostate has been observed. Cysts due to unusual size of the prostatic utricle have been mentioned elsewhere.

Malignant Tumors of the Prostate.—Both sarcoma and carcinoma of the prostate occur, the latter being much more frequent than the former.

Sarcoma.—Round-celled sarcoma is the commonest form; spindle-celled lymphosarcoma, myxosarcoma, and angiosarcoma have been observed. The

disease occurs chiefly in childhood and early adult life. It has been observed in infants. The progress of the growth is, as a rule, exceedingly rapid. Death has occurred in from three to six months. In children, life is seldom prolonged more than a year after the appearance of the symptoms. The tumor may reach a considerable size in a few weeks, and may fill the pelvis or appear in the perineum in a few months. In children the growths are usually soft and vascular. When sarcoma of the prostate occurs in the elderly, its progress is apt to be slower; the tumors are harder, and may remain encapsulated for a considerable time. Metastases and infection of the intrapelvic lymph nodes are either absent, or occur later and less frequently than in carcinomata. The symptoms begin, as a rule, with difficult urination, gradually increasing to complete retention; in many cases the passage of a catheter is impossible and suprapubic drainage becomes necessary. A very few cases have been operated upon successfully in adults.

Carcinoma of the Prostate.—Cancer of the prostate occurs late in life, while, as stated, sarcoma usually develops in children and young adults. The two common forms of cancer are adeno-carcinoma and medullary carcinoma; a third, slowly growing, form, analogous to scirrhus of the breast, was described by Fenwick. The two former types usually grow with frightful rapidity, while the latter may remain small for many months, so that the duration of life may be as long as three years.

While in the majority of cases the entire gland is soon involved, together with the prostatic urethra, the bladder, rectum, and seminal vesicles, yet the disease may run its course until death, including the formation of extensive secondary deposits in the pelvic and inguinal lymph nodes, together with metastatic tumors in the bones and other organs, without involving the entire gland. *The original tumor may remain small, and even pass unrecognized.*

The Symptoms of Carcinoma of the Prostate.—Owing to the fact that cancer of the prostate occurs chiefly in elderly men, who are or might be suffering from enlarged prostate, and that the early symptoms of both conditions are similar, prostatic cancer often remains unsuspected until the disease is far advanced. Just how often cancer develops in the hypertrophied gland and what causal relation, if any, exists between hypertrophy and cancer, is still not definitely known. The early symptoms are usually those of prostatic obstruction, with this rather characteristic distinction that, whereas in simple prostatic enlargement, frequent and difficult urination are the symptoms which attract the patients' attention, in cancer *pain* is an early and marked symptom, which often precedes all others. At first the pain is felt only during urination, but soon becomes continuous and severe. It is referred to the prostate, rectum, sacrum, and loins. It radiates into the genitals and thighs. Urination and defecation are accompanied by severe paroxysms of pain. Pain in the course of both sciatic nerves is not uncommon, and is considered a suggestive symptom. As stated, there are other cases in which the prostatic tumor causes no obstructive symptoms, and where the metastases and enlargement of regional

lymph nodes create the first suspicion of cancer. In addition to pain, *hematuria* is an early symptom in a moderate number of cases. It is usually slight, and occurs during or at the end of urination. Later in the disease, when the tumor has invaded the bladder and presents large ulcerated and necrotic surfaces, hematuria is often profuse. The cystitis which develops becomes more and more severe, and takes on toward the end a putrid and gangrenous character.

The progress of the disease is usually very rapid. Life is rarely prolonged more than a year after the appearance of symptoms. The entire pelvis may be blocked by cancerous masses in a few months. The patient rapidly sinks under pain, sepsis, cancerous cachexia, etc.

Diagnosis of Prostatic Carcinoma.—It is rare that a diagnosis of prostatic cancer can be made so early as to afford any hope of a radical cure. If the gland is diffusely invaded it may feel precisely like an ordinary glandular hypertrophy, and by the time the surgeon has realized from observing the extraordinary rapidity of the growth that he has to deal with malignant disease a radical operation is out of the question. When well advanced, rectal examination will reveal a large, hard, knobby mass, forming a solid infiltration of the pelvic floor and projecting into the rectum. The anterior wall of the gut may also be infiltrated or ulcerated. The infiltration may also involve the bladder at a rather early date. The presence of enlarged, hard inguinal and iliac glands will verify the diagnosis. When the tumor begins as a nodule in one lateral lobe, rectal touch will reveal a hard nodule in one half of the prostate, not necessarily of great size. These are the cases where metastases in the bones may be the first signs of serious illness, since the tumor of the prostate does not of necessity produce obstructive symptoms. The diagnosis, as in the former group of cases, can rarely be made early enough to permit an operative cure. Cancer of the bladder may be distinguished from that of the prostate by the use of the cystoscope, rarely capable of introduction in the latter condition, and by feeling the normal prostate in a case presenting the symptoms of bladder tumor.

CHAPTER XXXII

THE URETHRA

ANATOMY OF THE URETHRA

SUCH details of the anatomy of the penis as are of practical interest to the surgeon will be spoken of under appropriate headings. The anatomy of the *urethra* is of great practical interest, and will receive here separate attention. The details are partly adapted from Merkel. Though the urethra is a continuous canal, it is usually divided for purposes of description into three, sometimes into four, parts—namely: (1) Pars cavernosa; (2) pars membranacea; (3) pars prostatica. The proximal portion of the pars cavernosa may be distinguished as a fourth portion—pars bulbosa.

From a pathological and eminently practical point of view, the urethra may also be divided into an anterior and a posterior portion—i. e., the parts lying anterior and posterior to the compressor urethræ muscle, respectively. The *length* of the urethra is variable, and depends upon the length of the penis, as well as upon the condition of that organ, whether flaccid or erect. In the latter condition the penis is rarely subjected to instrumentation at the hands of the surgeon, so that the increased length of the urethra produced by erection may be here disregarded. It is, however, noteworthy that during erection the meatus gapes slightly, and thus affords an easy entrance for pathogenic organisms. The individual variations in the length of the penis cause the urethra to vary in length, in different cases, from 14 to 25 cm. (Sappey). The average length, according to Merkel, measured in frozen or formalized subjects, was 17.5 cm., a little less than 7 inches. About 0.5 cm. may be added to allow for the shrinkage occurring after death, due to the absence of blood in the erectile structures. Instruments for introduction into the bladder are usually given a length of from 24 to 36 cm. The length of the several portions of the urethra is as follows: Prostatic portion, 2 to 3 cm.; the membranous portion has an average length of 1 cm.; the cavernous portion about 14 cm.

The Caliber of the Urethra.—The caliber of the urethra is a matter of great interest to surgeons, and one which has in times past given rise to much controversy. Like other mucous canals, its walls are in contact unless distended by some foreign body. Upon section the canal has the form of a slit. In the prostatic portion half-moon shaped, and convex forward on account of the projection of the verumontanum from the floor of the canal. In the membranous portion it is star-shaped. In the cavernous portion the urethra forms

a transverse slit, which changes in the glans penis to a vertical slit. The physiological distention of the canal by the passage of the urinary stream does not exceed 5 to 7 mm. The urethra is, however, capable of much greater distention than this. The observations of the late Fessenden N. Otis were of the greatest value in this connection, and it was through the results of his work that the operation of litholapaxy, as practiced by Henry J. Bigelow, was rendered possible. Otis demonstrated that the adult urethra was capable of being distended to a circumference of at least 30 of the French scale, and further, that the size and distensibility of the individual urethra bore a definite relation to the circumference of the flaccid penis. To quote from Otis: He found, "that when the circumference of the flaccid penis was 3 inches, the circumference of the urethral canal was found to be at least 30 of the French scale. When it was $3\frac{1}{4}$ inches, the urethra had a capacity of 32. When it was $3\frac{1}{2}$, the capacity would be 34; $3\frac{3}{4}$ inches = 36; 4 inches = 38. When it was $4\frac{1}{4}$ to $4\frac{1}{2}$ inches in circumference, the capacity of the urethra would equal 40 or more. In every case the urethral caliber was over rather than under the figures above given. In a considerable majority contraction of the meatus (either congenital or from previous inflammatory changes) was present, and in these cases the measurements were made with the urethrameter, or after division of the contraction."

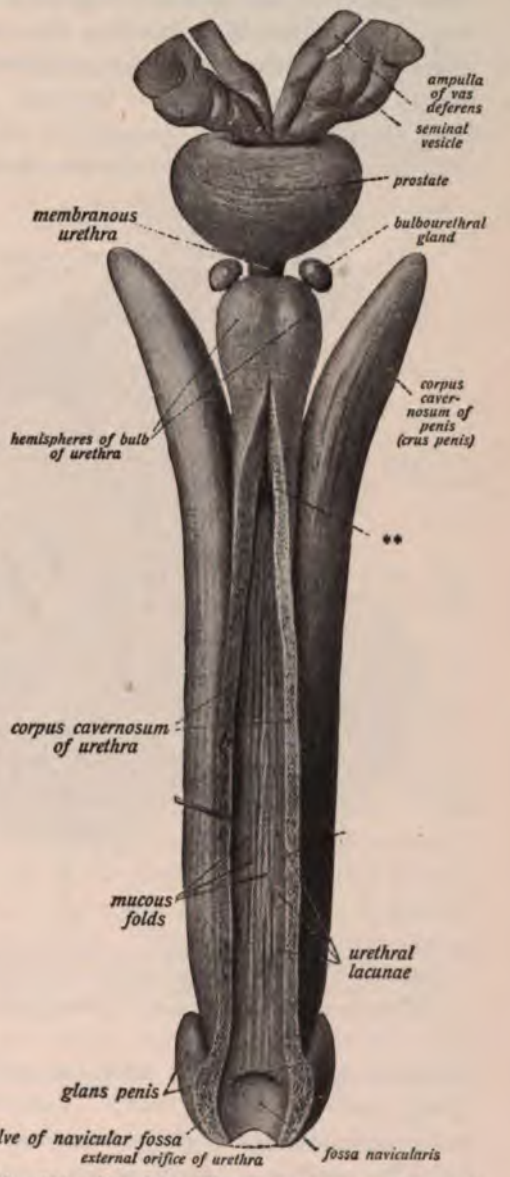


FIG. 211.—THE MALE URETHRA, WITH THE CORPORA CAVERNOSA OF THE PENIS, THE BULBO-URETHRAL GLANDS AND THE PROSTATE. (Watson and Cunningham, after Sobotta.)

Although it is certain that Otis's rule is not mathematically correct, and, as will be learned, exceptions must be taken to it as to certain parts of the canal, yet as a practical working rule for the surgeon it is of great value, notably in cases of stricture of the urethra.

Not all portions of the urethra are equally distensible. Some parts distend readily, others offer great resistance to distention. This depends not upon the urethra itself, but upon surrounding structures. Thus the meatus urinarius is often quite narrow and nondistensible, being surrounded by a dense fibrous ring. It is quite safe to assume that any instrument which passes the meatus will go through the rest of the canal without difficulty, if it be normal. Immediately behind the meatus is the *fossa navicularis.* Upon median section the fossa appears very wide, because the meatus is a wide, vertical slit. The fossa extends inward beneath the point of the corpora cavernosa, where the canal

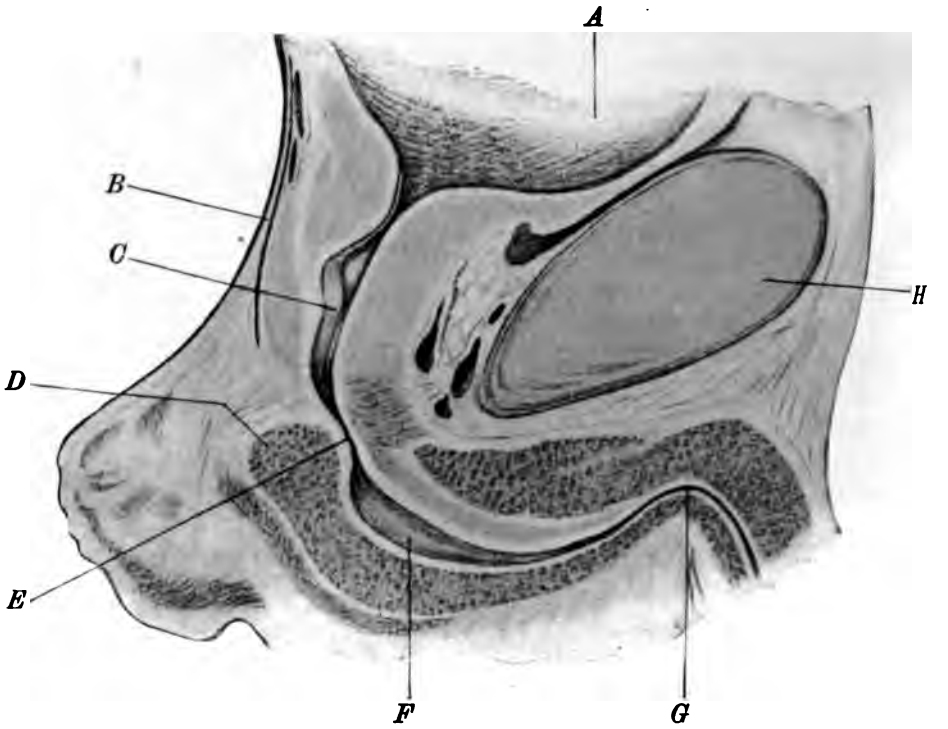


FIG. 212.—MEDIAN SECTION THROUGH THE URETHRA SHOWING ITS WIDER AND NARROWER PLACES. Natural size. *A.* Urinary bladder. *B.* Rectum. *C.* Colliculus seminalis. *D.* Bulb of the corpus spongiosum. *E.* Membranous urethra. *F.* Bulbous portion of the urethra sometimes known as the fossa of the bulb. *G.* Prepubic curve. *H.* Symphysis pubis. (After Merkel.)

continues backward of a uniform caliber throughout the pars cavernosa or spongy portion (see Fig. 213). Very commonly there is a marked diminution in the distensibility at the peno-scrotal angle, in average cases about 3½ inches from the meatus. Absent in some cases, this narrowing may be present in others to a recognizable extent without pathological lesion.

The Bulbous Portion.—The bulbous portion shows a distinct enlargement just in front of the opening in the triangular ligament (Sinus bulbi, Thompson; Fossa bulbi, Hyrtl). As elsewhere noted, this dilatation is most marked in flabby and elderly men. This portion of the canal and its junction with the

next or membranous portion is the most frequent site of tight, narrow stricture, though not the most frequent site of strictures of wide caliber. (See Stricture of Urethra.)

The Membranous Portion.—The membranous portion is one of the less distensible parts of the canal. Where the urethra passes through the anterior layer of the triangular ligament it is surrounded by a dense layer of fibrous tissue.

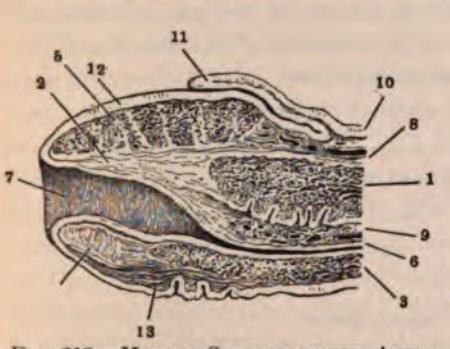


FIG. 213.—MEDIAN SECTION OF THE ANTERIOR EXTREMITY OF THE PENIS. (1) Corpus cavernosum penis. (2) Place at which the same tapers to a point. (3) Corpus cavernosum urethræ. (4) Median septum of the same. (5) Corpus cavernosum glandis. (6) Urethra. (7) Fossa navicularis. (8) Venous plexus of the dorsum penis. (9) Venous plexus of the urethral furrow. (10) Skin. (11) Prepuce. (12) Skin of glans. (13) Frenum of the prepuce. (After Henle.)

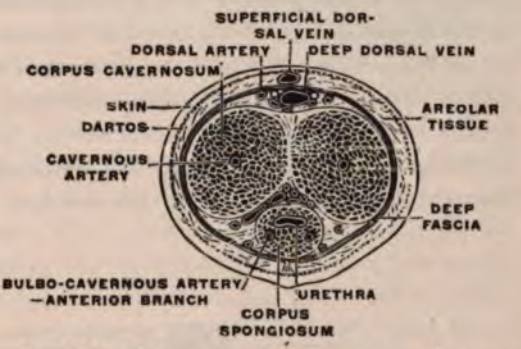


FIG. 214.—TRANSVERSE SECTION OF THE SHAFT OF THE PENIS, SHOWING THE BLOOD-VESSELS AND OTHER STRUCTURES. (After Woolsey.)

Hence, sounds and catheters pass this point with some difficulty, if of very large size. As elsewhere stated, in cases of marked enlargement or relaxation of the bulbous portion, instruments will often catch against this fibrous diaphragm. It may require not a little nice dexterity to lift the point of the instrument over the obstruction and cause it to engage in the proper channel. Only practice will enable the operator to overcome the obstacle readily and without damage to the urethra. When introducing a metal instrument it should be borne in mind that the sound is a lever of the first order, the long arm of which is in the surgeon's hand, and that force applied to this arm is greatly magnified in the short arm or beak of the sound. The utmost gentleness must therefore be used at this point. If the instrument catches, it may be withdrawn a little and again advanced; or the whole sound may be lifted toward the pubes, or a finger on the perineum or in the rectum may be used to lift the beak over the obstruction. In rough, careless hands, false passages are easily made at this point.

The Prostatic Portion.—The prostatic portion is again wider and much more readily distended. It is spindle-shaped on median section (see Fig. 212).

The Internal Urethral Orifice.—The internal urethral orifice or bladder end of the urethra appears to be quite narrow, but, as a matter of fact, is readily dilated when not surrounded by inflammatory tissue, and may be stretched on the living subject so as to admit the forefinger without tearing the mucous membrane.

Position and Curvature of the Urethra.—The position and curvature of the urethra are also of great consequence from a surgical point of view; more important, indeed, than the caliber of the canal. This is not true of the freely mobile pendulous portion contained in the penis. It is therefore customary to distinguish two portions of the urethra—a *pars pendula, pars mobilis,* or movable portion, and a *pars fixa,* or fixed portion. The beginning of the fixed portion is at the point where the suspensory ligament of the penis is attached to the dorsal aspect of the corpora cavernosa penis, thereby limiting the mobility of the organ. "While the surgeon is absolutely free in posturing the movable part, this freedom ceases at the beginning of the fixed portion, and here begin the difficulties of catheterization; beyond this point lie the places where an unskillful hand may do untold damage, and where an unlucky blow or fall may cause serious injury to the urethra. It is always to be borne in mind

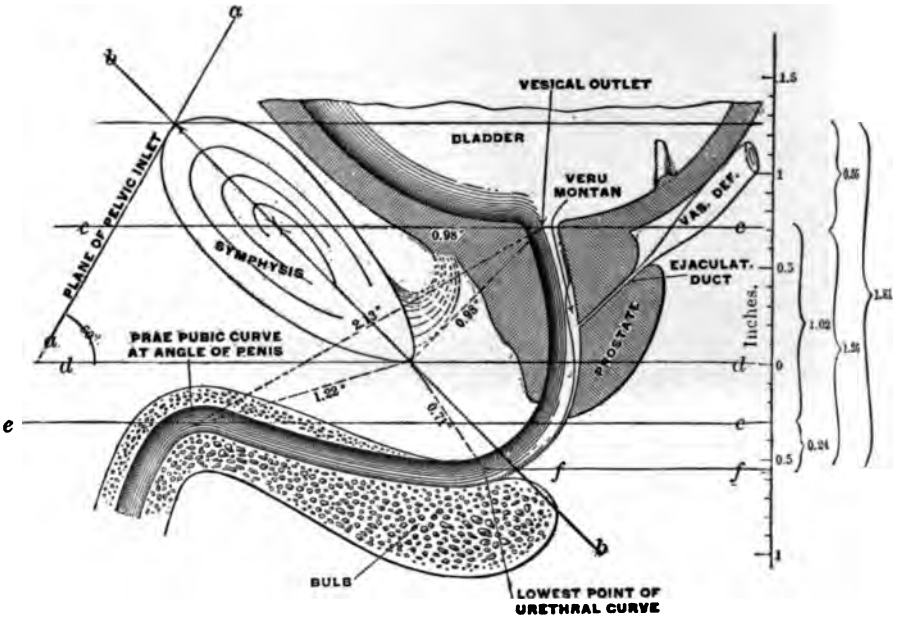


FIG. 215.—OUTLINE DIAGRAM OF THE CURVED PORTION OF THE URETHRA, SHOWING THE DISTANCES FROM AND THE RELATIONS OF THE DIFFERENT PARTS TO THE SYMPHYSIS. (Woolsey, after Testut.)

that the fixed portion lies exactly in the median line, and that in consequence an instrument must advance in this plane also. The curvature of the fixed portion of the urethra is determined by the relation of the canal to the skeleton, to the urogenital diaphragm, and to the prostate. When the penis is flaccid, two curves exist—a prepubic curve and a subpubic curve; the former belongs to the movable portion and is of no practical interest, the latter to the fixed portion and is of great practical consequence. Together these curves form a letter S" (Merkel).

While it is customary to speak of the entire subpubic curve as fixed, yet this is only strictly true of one portion of it—namely, the membranous urethra

as it passes through the triangular ligament. By the exercise of a certain amount of force the position of all but this portion may be considerably modified, and the curvature even obliterated. It is thus possible to introduce a straight instrument into the bladder, truly with some difficulty and by the use of a certain degree of pressure. Such instruments are introduced during the evacuation of stone fragments in the operation of litholapaxy and in viewing the posterior urethra through a straight endoscopic tube.

The Membranous Urethra.—The membranous urethra lies, on the average, a distance of 15 mm. from the lower border of the pubic symphysis. The entire fixed portion describes a curve concave forward and upward, whose radius is 25 mm. Various authors place the limits of the diameter of the circle between $3\frac{1}{4}$ and $4\frac{4}{5}$ inches. The chord of the arc described by the fixed portion is $2\frac{1}{5}$ to $2\frac{3}{4}$ inches in length. The curve is sharper in small, thin men and longer and flatter in large, stout men. The curvature of the prostatic portion of the urethra is more or less modified by the condition of other intrapelvic structures. When the rectum is distended, the prostate and urethra are pushed forward and the urethral curve becomes sharper. If the recto-vesical pouch contains distended coils of small intestine, the bladder being empty or moderately full, a similar effect is produced. If the rectum is empty and the bladder distended, the prostate and urethra are pressed downward and backward; the curvature of the urethra is flattened.

It is important to bear in mind the influence of age upon the urethral curve. We have already described the changes during advanced life in the curvature and length of the prostatic urethra, the result of prostatic hypertrophy. In male children the curve is much sharper, and when it becomes necessary to introduce a metal instrument into the bladder of a male infant, a special curve is essential in order to avoid undue violence. (See Fig. 190, illustrating the proper curve of a sound, catheter, searcher, or lithotrite for male children.)

The Mucous Membrane of the Urethra.—The mucous membrane of the urethra is smooth, and of a rosy-red or bright salmon color, notably in the fossa navicularis. Through the endoscope it is sometimes possible to distinguish two less vascular, narrow, longitudinal streaks upon the roof and floor respectively. In the pars cavernosa, spongy portion, the mucous membrane is arranged in finer and coarser folds, the former arranged in a network, the latter forming longitudinal ridges and furrows. One or two especially prominent folds are usually to be seen upon the dorsal wall. The orifices of the urethral lacunæ (Morgagnii) are visible, like needle punctures, ending in little blind pockets. They are arranged in longitudinal rows (see Fig. 211), and are most numerous along the dorsal median line. Some are found along the floor and others in each lateral angle of the urethral slit. They are present as far back as the peno-scrotal curve, seldom farther. They all run backward obliquely toward the root of the penis, are a frequent seat of chronic gonorrhea, and may engage the point of a fine filiform; therefore, when introducing such an in-

strument, one should try to keep along the floor of the spongy portion, where they are less numerous. Anteriorly in the roof of the fossa navicularis is the *lacuna magna*, distant one half to one inch from the meatus. It is nearly covered by a valvelike fold of mucous membrane—*the valvule of Guerin*. The lacuna is large enough to catch the tip of a small instrument. Along the entire length of the urethra there are found scattered glands—*Littré's glands*; they are of simple structure and too small to be visible to the naked eye. In the floor of the anterior part of the bulbous urethra the ducts of *Cowper's glands* emerge side by side; the openings are large enough to admit a bristle. The glands themselves lie between the layers of the triangular ligament on either side of the membranous urethra, embedded among the fibers of the *compressor urethræ muscle*, and close behind the bulb. The glands are as large as peas, and are one fifth of an inch apart. Their ducts are rather long—4 to 6 cm.; they run forward in the cavernous tissue of the bulb, and empty after penetrating the mucosa, as above described.

The finer structure of the mucous membrane of the urethra is of no great practical interest to the surgeon; suffice it to say that at the meatus and in the navicular fossa, the characters of flat, cutaneous, stratified epithelium are preserved, merging gradually into cylindrical epithelium as the end of the fossa is approached—at first simple, farther back stratified. In the prostatic urethra the epithelium comes to resemble more nearly the epithelium of the bladder wall.

CONGENITAL DEFECTS OF THE URETHRA

Entire absence of the urethra, the penis being present, has been observed in a few cases, but is exceedingly rare. Partial absence or closure of the canal at some particular point is fairly common. The most frequent point of closure is at the external meatus. Usually the meatus is covered by a thin membranous pellicle, caused to bulge from the pressure of retained urine. In many instances such a closure is ruptured before birth; in others it may readily be punctured with the point of a knife or a probe. In more marked cases the urethra may be absent in the glans penis merely, or throughout any part of the cavernous portion. In some cases *atresia of the internal orifice* of the urethra may exist, or such atresia may involve a considerable part of the prostatic or membranous urethra. These deformities are often combined with atresia of the rectum, or with a fistulous communication between the rectum and the bladder. Such children may be born dead. In a recent case, observed in the anatomical laboratory of the Columbia University, the fetus had a congenital atresia of the membranous urethra, extending a short distance into the cavernous portion. The back pressure had produced marked double hydronephrosis, dilatation of the ureters, and great dilatation, with final rupture of the urinary bladder. Other deformities existed—spina bifida, clubbed hands and feet. The child had lived a number of hours after birth. Labor occurred at the end of seven months. In some of these cases intra-uterine death and abortion have

occurred at from six to eight months, from interference with the fetal circulation by the distended bladder.

Cases have been observed in which the rupture took place through the urachus. The child, assuming that it survives, would then be born with a urachus fistula. The diagnosis of these various conditions is not difficult. If the child is born alive, distention of the abdomen and absence of urination would at once attract attention. The child would exhibit signs of pain and discomfort, would cry continually, and if not relieved by surgical means would speedily die.

Congenital Stricture of the Urethra.—Congenital narrowing of the urethra may occur at any point of the canal. The commonest sites, in the order of mention, are (1) the external meatus, (2) the anterior limit of the fossa navicularis, and (3) the membranous urethra (Keyes). In some of the cases evidences of urinary obstruction are present soon after birth; in others the symptoms develop during childhood; in others, not until manhood, or only indirectly when the individual acquires a gonorrhea which runs an unusually protracted course, healing being prevented by mechanical interference with the proper drainage of the canal. As stated, the most common site of congenital stricture is the meatus urinarius. The orifice may be so small as to seriously interfere with urination and require immediate attention. In other cases the child will grow to be five or six years old before symptoms occur. These will consist of frequent urination, general irritability, and other nervous disturbances. The condition is readily recognized by the attempt to introduce a sound into the urethra, and by observing that the urinary stream is small. F. N. Otis called attention to the fact that a very narrow meatus might produce marked disturbances in urination and a spasmodic contraction of the compressor urethræ muscle—a *true spasmodic stricture*. My own experience entirely agrees with his views. I have seen numerous cases diagnosticated as tight stricture of the membranous urethra, completely cured by division of the meatus.

Congenital Diverticulum of the Urethra.—A rare condition. The diverticulum always occurs on the floor of the canal, usually near the glans, sometimes farther back. The size varies from that of a small grape to that of a hen's egg. These diverticula may cause slight or serious symptoms. During urination the sac is distended, and forms a tense, rounded swelling, which the patient must empty by external pressure. In some cases a stricture may exist in front of the sac and cause serious obstructive symptoms. The diagnosis is plain from the history, and upon watching the patient urinate.

Double Urethra.—A rare congenital malformation. In these cases a groove exists upon the dorsum of the penis, usually just behind the glans. The groove leads backward to the orifice of a small mucous canal, which may end as a blind sac near the root of the penis, or somewhere in the course of the normal urethra, or in rare cases enter the bladder. The diagnosis is to be made by the introduction of a small sound or a probe. It is possible to acquire a gonorrhea in such a supernumerary urethra.

Epispadias and Hypospadias.—By the names epispadias and hypospadias are designated those congenital deformities of the urethra in which the canal fails to unite in the middle line more or less completely, and thus leaves an open furrow on the dorsal (epispadias) or upon the ventral surface (hypospadias) of the penis instead of the normal urethral tube.

Normally, at a rather early period of embryonic life the paired structures of either side are fused together dorsad and ventrad, to form a closed channel—the urethra. If the dorsal fusion fails, epispadias is the result; if the ventral, hypospadias. This fusion normally occurs before the corpora cavernosa have closed in, dorsad to the urethra, to unite in the middle line. Consequently, if dorsal fusion of the halves of the urethra fails, a deep, open groove remains between the separated corpora cavernosa. The deformity is explained by Thiersch, briefly, as follows: Epispadias, with or without exstrophy of the bladder, occurs as the result of an *early* separation of the cloaca into the urogenital sinus and the anal opening before the mesial union of the pelvis. As a consequence, the corpora cavernosa penis have not yet united into the genital tubercle, and the urogenital sinus comes to lie upon the dorsal aspect of the erectile bodies, which only unite later. Under these circumstances the urethra remains cleft, and if the cleft involves all the structures of the abdominal wall, the bladder also remains open in front (exstrophy of the bladder). When combined with exstrophy, the penis is imperfectly developed, small, and retracted close to the symphysis. The urethra is represented by a deep dorsal furrow, lined with more or less perfect mucous membrane. The prepuce is represented by a loose bunch of skin beneath the nearly bifid glans. In the much rarer incomplete cases the cleft may be confined to the glans or to the penile urethra. There is frequently an incomplete development of the vesical sphincter and incontinence of urine. The urethra may be so wide that a finger can be introduced into the bladder. The symphysis may or may not be united. The bladder may be herniated without exstrophy.

FIG. 216.—EPISPADIAS.
(New York Hospital, service of Dr. Frank Hartley.)

SYMPTOMS PRODUCED BY EPISPADIAS.—The most annoying, and a very common, symptom is incontinence of urine, complete or partial. The deformity

also involves *impotentia generandi*, and nearly always *impotentia cœundi*. The diagnosis, from what has been stated, needs no further comment.

Hypospadias.—Much the most common deformity of the urethra is incomplete union along its ventral surface—hypospadias. The urine then escapes through the abnormal opening. In all cases the defect is confined to that portion of the urethra in front of the triangular ligament, so that the sphincter mechanism is not interfered with, and these patients have normal control over the bladder. The deformity is to some extent hereditary, several examples having been observed in the same family. The deformity exists in three degrees: (1) Glandular or balanitic hypospadias; (2) peno-scrotal or penile hypospadias; (3) scrotal, or perineo-scrotal, or perineal hypospadias.

1. *Glandular Hypospadias.*—In the first degree the urethral opening is usually situated at the point where the frenum normally joins the glans, or just behind that point. In some cases there is a pit or groove in the glans at the site of the normal meatus, in other cases none. This is the most frequent form. It is not usually attended by any very annoying symptoms; sometimes the individual is unconscious of any deformity. In other cases there is slight dribbling at the end of urination, or a slight curvature of the glans downward during erection. Neither *potentia cœundi* nor *potentia generandi* are interfered with. In other cases the abnormal orifice may be strictured, or the glans may be deformed or twisted; the urine is delivered in a crooked or twisted stream, so that the individual wets his thighs or clothing. In some cases, combined with this grade of hypospadias, a membranous layer of skin joins the site of the frenum to the scrotum; erection may then be seriously interfered with (*virga palmata*).

2. *Peno-scrotal or Penile Hypospadias.*—The second degree—peno-scrotal or penile hypospadias—is much more rare than the first. In these cases the urethral orifice may be situated anywhere along the ventral surface of the penis as far back as the peno-scrotal angle (peno-scrotal hypospadias). The anterior portion of the urethra may be represented by a groove, by a blind canal closed either anteriorly or posteriorly, or no trace of the canal may be present. The penis is nearly always small, often deformed, bent downward, and adherent to the scrotum. The deformity and disability increase at puberty. Both satisfactory coitus and impregnation may be impossible. Urination is uncomfortable, and must be performed in the sitting or squatting posture, in order to avoid wetting the clothing and thighs. The urethral orifice may be strictured.

3. *Scrotal, Perineo-scrotal, Perineal Hypospadias.*—The third and most distressing form of hypospadias. In these cases the urethral opening is in the scrotum, or farther back in the perineum. The scrotum is divided into two lateral halves, between which is a funnel-shaped depression, lined with a red muco-cutaneous membrane, at the bottom of which is the urethral orifice. The penis is small and undeveloped, bent downward, and adherent to the symphysis. The whole apparatus resembles a vulva, with a large clitoris. Ordinarily a

testis is present in either half of the divided scrotum. If cryptorchism exists, the sex of the individual may be doubtful, notably if the general make-up is not of a distinctively masculine type. These are the only cases where difficulty exists in the diagnosis. Normal sexual relations are impossible. Urination is performed after the manner of women. In some cases other abnormalities exist at birth—atresia ani, or the formation of a common cloacal opening. (See also Congenital Defects of the Penis.)

I knew a man who had this degree of hypospadias, and in spite of the fact that he had two good-sized testes, he had been brought up as a girl and became a trained nurse in one of the large hospitals in this city. He apparently had had no idea that he was a man until he became ill and was examined by the surgeons of the hospital. His sex being made known to him, he gave up nursing, dressed as a man, learned to smoke, shaved, grew a heavy mustache, and entered a business career. He came under my observation on account of an inguinal hernia. He was very sensitive about his deformity, and very unhappy because he could not have sexual relations. He refused operation.

INJURIES OF THE URETHRA

Injuries of the urethra may be incised, punctured, or contused and lacerated wounds; the last are usually subcutaneous. Injuries of the corpora cavernosa will be considered in another place. The incised wounds occur for the most part in the penile urethra. They are rather rare injuries. An important distinction is to be drawn between wounds parallel to the urethra and those which are transverse or oblique. The former heal without difficulty, leaving no stricture behind. The latter are inevitably followed by stricture, if not united by sutures, and in many cases even when such sutures are applied. The immediate dangers of incised wounds of the urethra are urinary infiltration and peri-urethral cellulitis, or gangrene. The remote results in cases which do not heal *per primam* are urethral fistulæ and stricture. The diagnosis presents no difficulties. It is to be made by inspection of the wound, by the escape of urine from the wound during urination, and the appearance of blood at the urinary meatus. *Urinary infiltration* is indicated by a rapidly spreading, red, boggy swelling of the penis and scrotum, cellulitis and gangrene, and by the general symptoms of septicemia. Wounds penetrating the urethra through the scrotum are certain to be followed by urinary infiltration unless appropriate surgical treatment is at once applied. When the urethra is completely divided the proximal end retracts deeply, and a careful search and dissection may be necessary in order to find it.

Subcutaneous Injuries of the Urethra.—Far more frequent than open wounds are the subcutaneous ruptures and lacerations of the urethra. The injuries occur from blows and falls upon the perineum. The bulbous and membranous portions are the parts injured. The prostatic portion is rarely involved, and then only in cases of fracture of the pelvis, or where extreme direct violence

is applied to the perineum, as in cases of impalement. Injuries of the penile urethra from blunt violence occur almost always during erection, as during coitus, when the rigid organ is suddenly and forcibly bent, or in breaking a chordee. The immediate consequences are rarely serious, though stricture may follow. A case has, however, recently been reported in which the erect penis was actually torn completely away from the body by the hand of a woman. It was demonstrated by experiments on the cadaver that this was possible only when the penis was erect. The vessels were suitably injected to produce this condition.

The typical injuries of the perineum associated with contusion or rupture of the urethra occur from falls astride of some firm, narrow object—the rail of a fence, the pommel of a saddle, the rear wheel of a bicycle, etc.—or by direct violence, as from the kick of a horse or man on the perineum. Ruptures of the urethra may also be produced by falls or crushing injuries, causing fractures of the pelvis. The parts injured, the mode of production, and the nature of the lesions vary in different cases. When the blow or fall exercises pressure from before backward, the bulb is crushed against the anterior surface of the pubes, and the membranous portion is often torn as well. The urethra may simply be contused without actual rupture, or a considerable portion of the urethra may be irretrievably crushed, or the wall of the canal may be simply torn across. When the force is exerted from behind forward, as from a kick or blow just in front of the anus, the membranous portion alone is apt to be torn. When the pelvis is fractured the urethra may be directly crushed between the bony fragments of the pubes or penetrated by a sharp fragment, or the displacement of bone may tear the urethra at the junction of the membranous with the prostatic portion. In this last group of cases the prognosis is very serious. I recall a case of this kind upon which I operated some years ago:

A large muscular man fell into the hold of a ship, striking a beam in such a way as to fracture the horizontal and descending rami of the pubes upon either side. When brought to the hospital soon afterwards he was bleeding from the urinary meatus. He was unable to urinate and rapidly developed a hematoma in the perineum and scrotum. The pubic symphysis and the horizontal rami upon either side constituted a central, movable bony fragment. A catheter passed deeply into the perineum, but could not be made to enter the bladder. Perineal section was done at once. The membranous urethra was found torn away from the apex of the prostate. The tissues of the perineum were so torn and infiltrated with blood that the orifice of the prostatic urethra could not be found. A suprapubic incision of the bladder was made and retrocatheterization, in order to furnish perineal drainage. The patient made a slow and tedious convalescence. A stricture requiring the frequent passage of sounds formed in his perineum.

For purposes of description the subcutaneous injuries of the deep urethra may be classified as (1) contusions of the urethra, with or without tearing of the mucous membrane; (2) rupture of the urethra—(*a*) partial, (*b*) complete (Kaufmann). The two cardinal symptoms of rupture of the urethra are the escape of blood from the meatus and retention of urine. In the cases of mere

contusion both these symptoms may be absent. In these a painful, tender swelling will be formed in the perineum. A little blood may appear at the meatus, or the urine may be slightly blood-stained. The urine may continue to be passed normally, or, when the hematoma in the perineum reaches such a size as to compress the urethra, there may be difficult urination or retention. Catheterization is possible. In the cases where the urethra is wholly or partly torn across the amount of bleeding is considerable; a painful, tender swelling is formed in the perineum in a few hours, and soon spreads to the scrotum. Ecchymosis may also appear in the groins and upon the lower abdomen. Bleeding from the meatus may be profuse or slight. When the urethra is completely torn across, the distal end of the canal may be plugged with a clot, and little or no blood may escape from the meatus. In these cases there is invariably retention of urine. Catheterization is impossible. It is important to bear in mind that *the amount of bleeding from the meatus is no criterion of the severity of the injury to the urethra.* In cases of severe contusion to the urethra the early symptoms may be trifling, whereas the subsequent sloughing of the contused urethra may, after a number of days, put the patient in the gravest peril from extravasation of urine.

Course and Diagnosis of Subcutaneous Injuries of the Urethra.—The course of simple contusions is usually favorable. Not so those complicated by complete or partial rupture of the urethra. In these extravasation of urine inevitably occurs, unless immediate perineal section is made and adequate drainage provided for the urine. The phenomena of infiltration of urine observed in these cases are as follows: The patient holds his water as long as he can, but sooner or later attempts to urinate. If the urethra is nearly or wholly ruptured, little or no urine escapes from the meatus. The urine enters the loose connective tissues of the perineum, finds its way into the scrotum, beneath the integument of the penis, then into the subcutaneous tissues of the abdomen and thighs. Rapid decomposition occurs, with an intense septic and putrid infection of the infiltrated tissues. The skin is brawny, swollen, and dusky red; the scrotum may attain the size of a child's head. The subcutaneous tissues rapidly slough, the skin becomes gangrenous and greenish-black in color, over areas of variable size; sometimes the whole scrotum and perineum slough. Incision evacuates thin, stinking, greenish or brownish pus, mixed with foul urine, shreds of necrotic tissue, sometimes gas. The patient rapidly develops a mixed sapremic and pyogenic infection, with great prostration. Stupor, delirium, and coma end the scene in a few days, sometimes in forty-eight hours. In the cases which survive, either by spontaneous perforation or after incision, considerable loss of substance occurs. I have seen the testicles and spermatic cords entirely denuded up to the inguinal canals. In other cases several perforations occur here and there, from which urine, pus, and sloughs are discharged. If the patient survives, urinary fistulæ, opening in the perineum, through the scrotum, or upon the thighs, remain, through which most of the urine escapes. A tight stricture or actual obliteration of a portion of the canal

will be found at the site of the injury. Rupture of the urethra may be confounded with rupture of the bladder. (See Rupture of the Bladder; also sections on Hematuria.)

FOREIGN BODIES IN THE MALE URETHRA

Foreign bodies gain access to the urethra through the meatus or through the bladder in the largest proportion of cases. Rarely calculi are formed in the urethra itself, in pouches, or diverticula, or upon ulcerated surfaces, or in abscess cavities. If we exclude those cases in which portions of catheters introduced by the patient himself or by a physician or nurse are broken off in the canal, the patients are chiefly lunatics, or persons who have sought to obtain sexual satisfaction in an abnormal way. Among the articles introduced for this latter purpose may be mentioned needles and pins of all kinds, pipestems, twigs and sticks, fruit stones, beads, chewing gum, a leather thong, a safety pin, etc., to the end of a very long category. Pieces of catheter, or of bougies, or entire soft instruments, may be lost in the urethra. There appears to be a strong tendency for such objects to slip back into the bladder, favored by unsuccessful efforts at extraction. Round, smooth bodies tend to rest in the fossa navicularis, or in the bulbous portion, or to be stopped by an existent stricture. Sharp and irregular bodies tend to become impacted, and yet it is astonishing to observe the irregularity in form of certain bodies which reach the bladder. (See Vesical Calculus.)

The fate of foreign bodies in the urethra, when not evacuated upon urination or extracted, may be: (1) They pass into the bladder and form the nucleus of a stone. (2) They remain in the urethra and form the nucleus of an urethral calculus. (3) They cause pressure ulceration and perforate the urethra with the formation of an abscess, or the perforation is followed by urinary infiltration. Under either condition a urinary urethral fistula and stricture of the urethra may result.

Symptoms and Diagnosis.—When a portion of a catheter or a whole catheter is left in the urethra, the history may be readily obtainable; but if the patients are lunatics or children, or if the body has been introduced from a perverted sexual instinct, the history of its presence is apt to be wanting. Even after the body has been extracted, all knowledge of how it got into the urethra will usually be denied. When the body consists of a calculus descended from the kidney, there will usually be a history of more or less typical renal colic, yet such a history is often absent. Either the attack has not been severe and has been forgotten, or the previous symptoms may have been referred to the bladder—namely, painful and frequent urination, with or without changes in the urine. In some cases there will be a history of difficult and obstructed urination. I saw a case of this kind some years ago:

The patient was a healthy man aged thirty years. He was suddenly seized with a violent pain during urination. The stream suddenly ceased and he could

not empty his bladder. Under the influence of a hot bath and an opiate he was able with pain and straining to urinate in a feeble stream. The urine contained a little blood, and was otherwise normal. Upon introducing a sound, an obstruction was felt in the membranous urethra. The point of the instrument struck a hard substance, and a grating sensation was transmitted to the hand. The stone was pushed back into the bladder, crushed and evacuated. The fragments weighed forty grains. They consisted of urates with oxalate of lime. The patient left the hospital two days later quite well.

In another case the patient had a similar history but the retention of urine was complete. The stone had lodged in the fossa navicularis. I extracted it with forceps after enlarging the meatus.

When a stone or other foreign body becomes impacted behind a stricture the latter must be cut before the stone can be removed. It is always undesirable to incise the penile or scrotal urethra from without, lest a fistula remain. Perineal section will be necessary in certain cases. There are numerous ingenious forceps and other instruments intended to aid in the extraction of catheters, stones, and other foreign bodies from the urethra.

When a foreign body has been introduced from without, the symptoms will vary according to the shape and size of the body, and other physical qualities. Rough, large, and sharp bodies will produce symptoms at once—namely, dysuria, or retention of urine. In some cases dysuria will be followed by retention, owing to the swelling and inflammation of the urethral wall caused by pressure. When the body remains in front of the bulb, palpation of the urethra will usually permit the surgeon to detect its presence. If it lies in the membranous portion it may sometimes be felt by rectal palpation. If a body remains in the anterior urethra, its exact character and often the best means of extracting it may be determined by inspection through an endoscopic tube. If the body is still movable the surgeon should be careful not to let it get away from him and slip into the bladder. A finger should be kept constantly pressed upon the urethra behind the body during the efforts at extraction. In some cases the escape of the body into the bladder has been prevented when it was soft by transfixing the urethra and the body with a needle. Smooth foreign bodies, if not large, may produce but slight symptoms for the time, and the same may be true of calculi which have formed in the urethra itself. The patients may notice nothing but slight obstruction to urination, with some muco-purulent urethral discharge. After a time pressure ulceration will cause increased pain and dysuria. Retention will finally occur, or perforation of the urethra with abscess formation, resulting in urinary fistula or in infiltration.

Urethral calculi, whether they have come from the bladder or have originated in the urethra itself or have formed about a foreign body, may reach a considerable size. This is notably true of calculi formed in urethral pouches or diverticula; when so situated they do not necessarily produce any marked symptoms. Multiple calculi in the urethra have been observed. In certain cases the diagnosis of foreign bodies in the urethra is aided by the use of the X-rays.

CHAPTER XXXIII

DISEASES OF THE URETHRA

GONORRHEA AND ITS COMPLICATIONS

Acute Gonorrhea—Acute Specific Urethritis.—Acute gonorrhea, the most common of all venereal infections, is an acute purulent inflammation produced by infection with the specific micro-organism of gonorrhea—*the gonococcus of Neisser.* The disease is usually acquired during sexual intercourse with a woman afflicted with a gonorrheal discharge. Other sources of infection are possible; among such may be mentioned infection from the seats of infected water-closets, from infected towels and other linen, from infected urethral instruments. The epidemics of gonorrhea among both male and female children in hospitals, asylums, etc., demonstrate that mediate contagion is not only possible, but very frequent.

(For the microscopic characters of the gonococcus, see Bacteria Concerned in Surgical Infections; also Urethral Shreds.)

Method of Infection.—Mere undisturbed contact of pus containing gonococci, with the healthy mucous membrane of the urethra, is all that is necessary to insure infection. Immunity from gonococcus invasion is, so far as I am aware, unknown. The flat epithelium of the fossa navicularis appears to be resistent to the gonococcus, yet the aspirating action of the urethra, produced by the to-and-fro movements of the penis during coitus, is usually sufficient to bring the gonococci-bearing discharge into contact with the cylindrical epithelium of the penile urethra, where they find a favorable soil.

Period of Incubation.—The first symptoms appear after a period of incubation, which seems to vary within rather wide limits. One to fourteen days are the limits usually given; on the average six days. An incubation of less than four days has been rare in my experience. In those cases where a discharge has appeared less than forty-eight hours after exposure, I have assumed that the disease was an outbreak of a former uncured, though latent, attack, or that the infection occurred in a urethra already the seat of chronic gonorrheal inflammation.

Symptoms of Acute Gonorrhea.—The symptoms of acute gonorrhea are unfortunately so well known that they scarcely require description; briefly they are as follows: A few days after exposure the patient notices an itching or burning sensation at the meatus urinarius; upon inspection, the lips of the meatus are found glued together, and slightly swollen. A few hours later a

little sticky, opalescent discharge may be seen in the orifice. A slight burning sensation is felt during urination. The following day the discharge becomes more profuse and distinctly purulent. The lips of the meatus are swollen, puffy, and reddened. Pain on urination becomes more marked, until an intense burning sensation accompanies the act. As one patient described it to me, he felt as though he were urinating fish-hooks. After three or four days the disease is fully developed. The discharge is profuse, thick, and creamy yellow; later on it often assumes a greenish tinge from the presence of blood, or is even distinctly blood-stained. Painful erections occur at night. The patient sleeps badly; no sooner does he get warm in bed and fall asleep than he is awakened by the pain of a new erection. Actual chordee with bending of the penis occurs in a large proportion of cases. The corpus spongiosum becomes infiltrated with inflammatory material; its elasticity is lost; it cannot stretch sufficiently during erection, and thus acts like the string of a bow to cause a bending of the erect corpora cavernosa. The pain accompanying chordee is intense. Efforts on the part of the patient to straighten the organ may cause rupture of the infiltrated tissues of the corpus spongiosum with sharp bleeding, often followed by stricture. During the early days of the disease there may be a slight rise of temperature, loss of appetite, and moderate prostration. The urinary stream is diminished in size, and may be forked or twisted. Frequency does not occur until the posterior urethra is involved. When stricture of the urethra exists, retention may occur. There are subjective sensations of pain and tenderness along the penile urethra, and reflex pains in the groins, inner surface of the thighs, in the lumbar region, and the testes. If the foreskin be long and tight, retention of the purulent discharge may cause balanoposthitis, with swelling and inflammation of the foreskin and general integument of the penis. Phimosis is common, and paraphimosis may occur.

Frequent and very painful nocturnal emissions may occur during the acute and subacute stages of the disease. The acute stage of gonorrhea lasts, when uninfluenced by treatment, about three weeks. At this time the symptoms begin gradually to subside, assuming that the posterior urethra has not been invaded. Pain on urination ceases, painful erections no longer occur, the discharge diminishes in quantity, becomes muco-purulent and more watery. The duration of the subacute stage is very variable. In some cases it is rapidly cured by treatment; in others, treated or untreated, it passes into a chronic state, vulgarly known as gleet, which may last for months and years. In the last stages of a gonorrhea which is getting well, the symptoms consist merely of a single drop of muco-purulent discharge, which may be expressed upon separating the glued lips of the meatus in the morning. Finally, this disappears, and the patient, assuming that no complication exists, is well.

Diagnosis.—Clinically, the diagnosis of acute gonorrhea in a man previously healthy is so simple that in many cases the aid of the microscope may be dispensed with. There is a history of recent exposure. The virulent char-

acter of the inflammation is shown by marked redness and swelling of the meatus, by the profuse purulent discharge, and by intense *ardor urinæ*. In these cases the diagnosis is certain. In other cases the onset is more gradual; the discharge is at first slight and muco-purulent; gonococci may not appear for several days. In these, as in all cases of purulent urethritis, doubt may at first exist as to the specific nature of the trouble; if the disease is gonorrhea, gonococci will be found in the pus as soon as the discharge is well established—namely, after two or three days.

A group of cases of frequent occurrence are those of recurrent or relapsing gonorrhea. In such it may be difficult or impossible to say whether or not the patient has a new infection. In both instances gonococci are usually present. It has seemed to me that in the recurrent or relapsing cases the gonococci were often more numerous than in new infections. In the former group, however, they disappear very rapidly under local treatment; more rapidly than in the latter. Other differential points are as follows: A recurrent attack has no period of incubation, or a very short one. A fresh infection has an incubation, lasting usually five or six days, rarely less than four. A recurrence is often accompanied at once by the symptoms of posterior urethritis—i. e., frequency, both portions of the urine purulent; *a fresh infection never*, if the urethra was previously healthy. A *fresh infection* is usually attended by a swollen meatus and *ardor urinæ*. In recurrences, though the discharge may be profuse, there is rarely much *ardor*, and the meatus is not apt to be swollen, though exceptions to this may occur. While this differentiation between a new infection and a recurrence is only of moderate interest to the surgeon, it is often of very great interest to the patient, since it may involve in his mind the question of the fidelity of his mistress, or even of his wife. Manifestly, the surgeon is rarely able to answer the question with certainty, and it will nearly always be wiser, for the sake of the peace of mind of the patient, to assure him that his troubles are due to the outbreak of a former infection. (See, however, the following section.)

The Cure of Gonorrhea.—An important question, and one which every surgeon is called upon to answer many times, is this: "When is a gonorrhea cured?" The opinions of various observers upon this point have varied greatly. On the one hand it has been alleged that a man once infected with gonorrhea is or may be infectious continuously or at intervals throughout his life or for an indefinite period, and this in the absence of all evidence of disease of the genito-urinary tract. On the other hand, it has been believed that, even in the presence of a chronic purulent urethritis following acute gonorrhea, if the discharge contains no gonococci the individual is not contagious. The wise surgeon will base his conclusions upon careful clinical and bacteriological observation of each case, continued during a considerable period. Certain it is that the vast majority of cases of gonorrhea in men get well after a time absolutely, and cease to be contagious. In a good many, however, the disease becomes chronic, is accompanied by posterior urethritis, by infection of the deeper

crypts and follicles of the urethra, by prostatitis, epididymitis, seminal vesiculitis, more rarely by pyelitis and infection of the kidney. Some of these may remain continuously or intermittently contagious for an indefinite period, how long it is hard to say. Thus the cases may be divided into several groups. In some cases the discharge ceases; pus and shreds disappear from the urine; neither the secretion from the urethra, the centrifuged urine, nor the expressed secretions of the prostate and seminal vesicles show the presence of gonococci. Culture experiments are negative. Such patients, if the findings remain negative for several months, are certainly well. Professor Ultzmann, of Vienna, used to say that "if a man can copulate and drink without any return of his symptoms, he is well, and no longer contagious." I believe this rule is a safe one.

In other cases the patients do not completely recover. They continue to have a morning drop of urethral discharge. If the urethritis is anterior merely, the urine will be clear, but will continue to contain shreds of pus, and these persist even after the visible discharge has ceased. Such shreds represent superficial, unhealed erosions of the mucous membrane, or are the contents of inflamed crypts and follicles. Some of these cases relapse from time to time after coitus, alcoholic indulgence, or overfatigue. The discharge again becomes profuse, and contains gonococci. These cases are certainly contagious—perhaps not all the time, but surely some of the time—and remain so until the relapses cease. If shreds alone remain, they may be examined from time to time for gonococci; but even though none are found, if the shreds consist chiefly of pus cells the patient cannot be pronounced free from possible contagion. When the shreds are seen to consist chiefly or solely of epithelial cells, on the other hand, the process is healing, and if no change in their character occurs after coitus and drink, the patient may be pronounced cured. The author would not have it understood that he advises his patients to practice illicit sexual intercourse or to drink. He has found, from experience, that such suggestions are, as a rule, quite unnecessary.

Nongonorrheal Urethritis.—Acute inflammation of the urethra, accompanied by a purulent discharge, may occur without the presence of the gonococcus from a variety of causes. Among them may be mentioned trauma, the ingestion of alcohol and of certain drugs; diathetic causes; further, from excessive sexual intercourse and masturbation, from chemical irritants. Among the traumatic causes are wounds and contusions of the urethra from external violence; the rough passage of sounds and catheters; the irritation produced by leaving a catheter continuously in the urethra (*catheter à demeure*); the presence of an impacted calculus or other foreign body in the urethra.

The excessive use of alcohol, notably if combined with excessive sexual intercourse, is capable of causing urethritis, *a fortiori*, if the urethra is already damaged by previous attacks of inflammation or is the seat of stricture. It is said that the internal administration of drugs having a selective action upon the genito-urinary tract is capable of inducing urethritis—cantharides and turpentine, for example. Among other drugs of which the same is alleged are

arsenic and iodid of potassium. In Germany it is believed that large quantities of beer may cause a mild urethritis—the so-called "Bier Tripper." It is believed in England, though the belief is less widely current in the United States, that the gouty or rheumatic diathesis, when the urine is very acid, may be responsible for mild forms of urethritis; indeed, it is conceivable that urine loaded with crystals of uric acid might act as a mechanical irritant to the mucous membrane. That irritating injections of nitrate of silver, bichlorid of mercury, or chlorid of zinc, etc., may cause inflammation of the urethra goes without saying. In general, simple urethritis runs a far less stormy course than gonorrhea, and responds readily to treatment. In many instances the nonvenereal nature of the condition will be plain from the history. In others it will not, and a distinction can only be made by the presence or absence of the gonococcus. In some cases the disease runs a fairly severe course. Much the most common cause is sexual excess, combined with alcohol, though in my experience these cases are common only in men whose urethræ have been previously damaged by gonorrhea. The patient may not have had gonorrhea, nor any symptom referable to his urethra, for many years; after a sexual and alcoholic debauch he observes a urethral discharge; he is examined by a surgeon, who discovers a stricture, often of wide caliber. Though the discharge does not contain gonococci, it will not get well until the stricture is suitably treated.

It is noteworthy that marital coitus, however excessive, is very rarely followed by urethritis if the husband and wife have previously been free from gonorrhea; nor does coitus with a healthy woman during menstruation produce a urethral discharge. The popular belief in this latter causation arises, no doubt, from the fact that a woman with uterine and tubal gonorrhea is more likely to be infectious during this period.

Posterior Urethritis.—Inflammation of the prostatic and membranous urethra, and of the *trigonum vesicæ*, of greater or less severity, occurs in a large proportion of cases of gonorrhea; in so large a proportion that posterior urethritis is to be regarded rather as a regular sequel to acute gonorrhea than as a complication. *Acute* posterior urethritis is nearly always due to gonorrhea. Other forms of posterior urethritis occur, due to trauma from instrumentation, to calculus, tuberculosis, prostatic hypertrophy, to tumors of the prostate and bladder; but they are not preceded by an acute anterior urethritis, and are usually slight, subacute, or chronic, and merely subordinate parts of a symptom-complex having other and definite characters. Masturbation and sexual excess may produce a mild catarrhal posterior urethritis, never of a severity comparable to the gonorrheal variety. Stricture of the urethra is often accompanied by posterior urethritis, but this, again, is of gonorrheal origin in most cases. Posterior urethritis—or gonorrheal cystitis, as it is sometimes called—is usually confined to the prostatic urethra and *trigonum*. A generalized gonorrheal cystitis scarcely occurs except in chronic cases, and then is usually, though not always, the result of a mixed infection. (See Intersti-

tial Cystitis and Cicatricial Bladder.) The further extension of the gonorrheal process from the posterior urethra is usually to the glandular elements of the prostate, through the ejaculatory ducts to the epididymis and seminal vesicles, rarely to the ureter and kidney. A hemic infection to the endocardium, to the joints, muscles, tendon sheaths, eye, etc., is not infrequent.

Symptoms.—The onset of acute posterior urethritis produces a marked change in the symptoms of gonorrhea. The patient now has what he did not have before—*frequent and precipitate urination*, together with pain during and after the act of a different character from that he has previously suffered. In addition, the urethral discharge is diminished in quantity. If the patient, during acute anterior urethritis, be caused to urinate in two glasses, the first portion passed will be cloudy with pus and shreds, the second will be clear. After the onset of posterior urethritis, both portions of urine will be evenly clouded with pus.

The *pain* during urination is felt in the perineum and glans penis, ending in a sharp spasm of pain as the last few drops of urine are expelled and the muscles close on the inflamed prostatic urethra. Acute posterior urethritis seldom occurs before the third week of gonorrhea, unless the infection has been carried backward by the introduction of instruments. It is believed by many surgeons that injections into the anterior urethra are responsible for posterior urethritis in a large proportion of cases. This may be so; nevertheless, posterior urethritis is common enough, though no injections have been used. As predisposing causes may be mentioned the use of alcohol, sexual excitement, active exercise, notably horseback and bicycle riding; further, a general flabby habitus; in these cases, the external sphincter being feeble, the infectious discharge may more readily pass into the prostatic urethra.

Briefly described, the signs and symptoms of acute gonorrheal posterior urethritis are as follows: Frequent urination, with tenesmus, by day and by night. In the most severe cases the patient must urinate every few moments, and is not relieved when the bladder is emptied. There is severe pain during and at the end of urination, felt in the glans penis, the rectum, and perineum. The urine is evenly purulent throughout; the last drachm or two usually contains blood. The urine is *acid*, quite different from the ammoniacal urine of chronic cystitis with insufficiency. There is a constant dull pain in the sacrum and a sense of weight and fullness in the rectum and perineum. The discharge from the anterior urethra is diminished, or may even cease, to return again when the deep urethra improves. Rectal examination finds the prostate hot, throbbing, and tender, often swollen.

Constitutional symptoms are not usually marked, though in some cases there may be a rise of temperature, moderate prostration, anorexia, etc. A distinct chill and high fever usually points to some other serious complication, notably to abscess of the prostate.

Duration.—The duration of posterior urethritis is indefinite. In some cases, under rest and suitable treatment the inflammation is cured in days or

weeks. In others it becomes chronic, and lasts for months or years, or leaves the patient with a crippled genito-urinary apparatus for the remainder of his life.

Chronic Gonorrhea.—Chronic Anterior and Posterior Urethritis.—While many cases of gonorrhea get well under favorable conditions in a few weeks—*rarely less than six*—others, treated or untreated, are prolonged indefinitely, and then constitute chronic gonorrhea. When the anterior urethra is the seat of chronic inflammation, the diagnostic sign consists of a mucopurulent urethral discharge, more or less abundant, commonly known as *gleet*. Such a discharge may be so slight as to produce merely a gluing together of the lips of the meatus in the morning, and a single drop of discharge, or so profuse as to stain the clothing. The amount of discharge varies much from time to time, and is prone to increase in amount from slight sources of irritation, such as sexual excitement, coitus, the use of alcohol, violent exercise, overfatigue, etc. The causes of the prolongation of the inflammation are varied. Among them may be mentioned posterior urethritis, a narrow meatus, or the formation of a stricture. There may be granular patches of unhealed inflammation in the mucous membrane, beneath which lie areas of submucous cell infiltration or infection of the deeper glandular follicles of the mucous membrane. Depressed states of general health, anemia, tuberculosis, syphilis, and other constitutional diseases may all serve to prolong the course of the disease.

Severe infectious diseases, such as typhoid fever, sometimes cause the cessation of an acute or chronic gonorrheal discharge. Upon recovery from the typhoid fever the gonorrhea may or may not return.

Diagnosis.—Subjective symptoms are usually wanting, though slight itching along the urethra or at the meatus, or slight burning during urination, may be present. It is highly important in these cases to determine the special cause of the chronic process, and to discover whether or not the posterior urethra is infected, as also the condition of the prostate, seminal vesicles, and testes. If there is much discharge, it will be unwise to introduce instruments into the urethra for diagnostic purposes until the intensity of the inflammation and the quantity of discharge has been reduced to a minimum by suitable injections.

The diagnosis of anterior and posterior urethritis may often be made by one or other of the following procedures:

The Two-glass Test.—The patient is allowed to urinate in two glasses, having been previously requested to hold his water for several hours. Two or three ounces are collected in the first glass, the remainder in the second. If the first portion contains pus and shreds, while the second is clear, anterior urethritis is surely present; posterior urethritis, if present at all, is only of slight severity. If both portions are purulent, the first but slightly more than the second, and the patient has a urethral discharge, anterior urethritis, and probably posterior urethritis, exist. A generalized cystitis, or a renal source, cannot, of course, be excluded with certainty by this means, but when posterior urethritis of such intensity as to render the urine distinctly cloudy is present,

the subjective symptoms of pain and frequency will usually be marked. Another measure is sometimes useful: A soft-rubber catheter is passed down to the bulbous portion, and through it the anterior urethra is washed clean with salt solution. The catheter is then withdrawn and the patient urinates in a glass. Pus and shreds in the urine passed come from the posterior urethra, or bladder, or higher up. The anterior urethra may be injected with a colored solution—methylene-blue, for example. The solution is permitted to remain for a minute in the urethra. The colored solution is permitted to escape. If, then, the patient urinates, blue shreds in the urine come from the anterior urethra, others from the deeper portions of the genito-urinary tract. Another method may be used: The patient urinates in three glasses. After the first portion is collected, the seminal vesicles are milked *per rectum*, and a second portion of urine is collected. A third glass is then used, in which the patient empties his bladder. If the second portion is notably more purulent than the first and third, the seminal vesicles are inflamed. In order to be conclusive this differentiation must be made with the microscope.

The Diagnostic Value of Shreds in the Urine.—While the diagnostic value of shreds in the urine has been already mentioned in several places, it will be well to discuss the topic more in detail. From the macroscopic appearances of shreds some inferences may be drawn as to their source and character. From the microscopic appearances some definite information may be gained as to the stage of the inflammatory progress, whether proceeding toward recovery or not, and further as to the presence or absence of gonococci.

Macroscopically, we may make the broad differentiation that shreds which quickly sink to the bottom of the vessel usually consist of pus, while shreds which float or remain long suspended in the urine contain mucus and epithelium, with a few leucocytes, and either indicate a healing process or have their origin in the prostatic urethra, and are without pathological significance. It is to be borne in mind, however, that the most important question in regard to shreds is, Do they contain gonococci or not?

The following classification of urethral shreds, given by Keyes, appears to be practical, and agrees with my own experience:

Shreds may be classified under five heads. All the varieties or only one may be present in the same specimen. They are: Small granular flakes, usually very numerous; threads; tadpole shreds; angular pieces; cottony shreds.

The small granular flakes usually come from the anterior urethra. They settle only slowly in the urine, and consist of masses of ovoid or flat epithelia, with a greater or less number of pus cells.

The threads are slender white bodies, sometimes of considerable length. They are heavy, and settle at once to the bottom. They consist of a dense aggregation of pus cells, massed together in a rope. They come from the anterior urethra, indicate a fairly acute process, and often show gonococci upon staining. When the gonococci are few, double staining is a useful measure: Gram, followed by any of the differently colored anilin stains—fuchsin, Bis-

marck brown, etc. We are thus able to differentiate most of the cocci resembling the gonococcus from the true coccus of gonorrhea, the latter being negative to Gram.

The *morphology* alone of the gonococcus is not sufficient to identify it *positively*. I quote from Cole (Osler's "Modern Medicine," vol. iii, page 89): "Streptococci, especially when obtained from animal exudates, may occur in biscuit-shaped pairs. Most closely related, however, to gonococci are Micrococcus meningitidis and micrococcus catarrhalis. In morphology and staining properties both of these resemble the gonococcus, but differ from the latter in growing on ordinary culture media. While these organisms are not likely to cause errors in the study of urethral exudates, in the more unusual extragenital lesions this possibility must always be borne in mind. On the other hand, gonococci in cultures do not always show the typical form mentioned above, but may appear in somewhat oval pairs, or as rounded individuals. These organisms grow best on a culture medium composed of hydrocele fluid, one part, and nutrient agar-agar, two parts; or, even better, on a medium composed of human blood, one part, and agar-agar, three parts. Up to the present time no animals except man have been shown to be truly susceptible to infection with the gonococcus."

The comma, or tadpole shreds, are ovoid or globular masses of pus, with a taillike projection. They are heavy, and sink at once to the bottom of the vessel. They often contain gonococci. They originate in the posterior urethra, and represent the purulent contents of an infected follicle, or the purulent scab covering an eroded surface of mucous membrane, rolled up into a ball-like mass by the stream of urine.

The angular pieces are supposed to originate more often than otherwise from the inflamed urethra behind a stricture. They consist of pus.

Cottony threads are often seen, in otherwise perfectly clear urine, as a single large, filmy, ropelike mass of mucus which floats in the urine. Such masses originate in the prostate. Under the microscope they are found to contain mucus, round cells, flat epithelial cells, sometimes crystals of oxalate of lime. They are not pathological.

As elsewhere stated, the progress of the cure in cases of chronic urethritis may be watched with advantage by placing the shreds from time to time under the microscope. While the inflammatory process is still active the shreds consist solely of pus. When healing has commenced, some epithelia will be seen mingled with the pus cells. When the healing process is complete, the shreds will be seen to consist chiefly of epithelia, with but few round cells. It is to be borne in mind that such shreds may persist in the urine for a long time after the patient is really cured. Indeed, I have seen many cases where their occurrence seemed to be permanent, and yet these individuals were certainly not infectious.

The Endoscope or Urethroscope.—While in the diagnosis of diseases of the urethra ocular inspection of the urethral mucous membrane may be dispensed

with in many cases, yet for an accurate diagnosis in certain cases of rebellious chronic urethritis the urethroscope is of decided practical value. The lesions

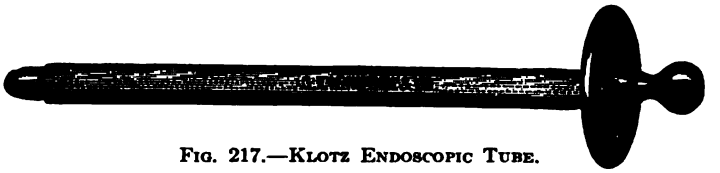


FIG. 217.—KLOTZ ENDOSCOPIC TUBE.

of the mucous membrane may thus be accurately located and their character determined. In a few cases only, as far as my personal experience goes, th urethroscopic treatment of urethral lesions is indispensable.

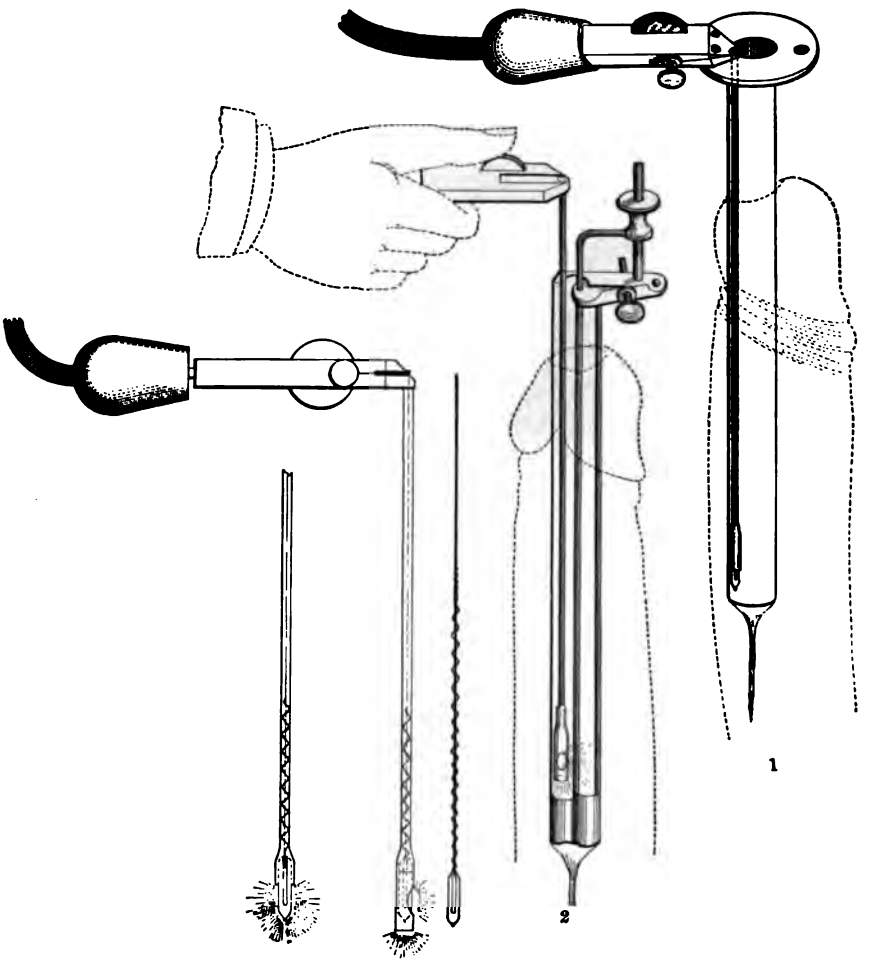


FIG. 218.—THE CHETWOOD URETHROSCOPE. (Keyes.)

After many modifications the urethroscope has been developed into a ver perfect apparatus. The instrument consists of a straight metal tube (Klot

tube), carrying a suitable obturator, together with an electrical connection for illuminating its interior. The electric part may be omitted and a head mirror used to reflect light down the tube.

In the electric urethroscopes, one of two methods of illumination may be used. In the instrument of Otis a small inclosed electric lamp, having a lens in front of it, is used to throw a strong beam of light down the tube. In the other a small electric light is passed down the interior of the tube itself, and remains there during the examination. The originator of this device was, I believe, Dr. Henry Koch, of Rochester, N. Y., the invention of the cold lamp by W. C. Preston, of that city, having rendered it possible. The instrument is known in New York as Chetwood's urethroscope. F. T. Brown's wire urethral speculum is very useful in certain cases (see Fig. 219). Both methods illuminate the urethra in a satisfactory manner. On the ground of convenience and cleanliness, I much prefer the instrument of Otis (see Fig. 220).

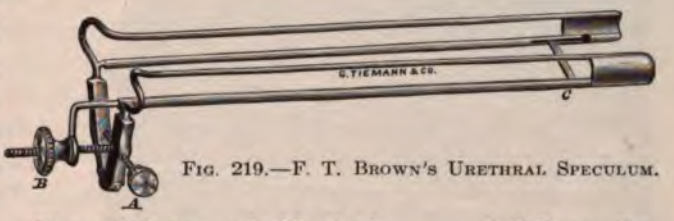


FIG. 219.—F. T. BROWN'S URETHRAL SPECULUM.

FIG. 220.—THE OTIS ELECTRIC URETHROSCOPE. Much the most satisfactory source of illumination for endoscopic work, in the opinion of the author.

In describing the diagnostic use of the urethroscope it is to be borne in mind that, as is the case with so many other special diagnostic aids, practice and experience are necessary for the proper interpretation of the things seen. The observer must be familiar with the appearances of the normal canal, varying as it does in different parts, before he is in a position rightly to study and interpret its pathological changes. A brief description of the appearances of the normal urethra will be found below.

The technic of endoscopic examination is as follows: A sterilized tube is selected as large as will pass readily through the meatus. Iceland-moss jelly is the best lubricant. As short a tube as will reach the spot to be examined is desirable—from four to five inches for the anterior urethra, from five to six inches for the prostatic urethra. Tubes of a caliber of 24 French and upward are much more useful than smaller ones. The patient may lie flat on his back for examination of the anterior urethra, but must be in the lithotomy position for the examination of the prostatic portion. The introduction of the tube into the urethra is made by holding the penis vertical, and inserting the ob-

turator through the meatus, pushing it gently onward until resistance is felt, or until it reaches the bulb. If the anterior urethra alone is to be examined, the obturator may then be withdrawn and the examination commenced; if the prostatic portion also, then the instrument must be slowly rotated downward, nearly or quite to the horizontal, until it engages in the hole in the triangular ligament, when it is pushed on gently into the bladder. The passage of a straight instrument into the bladder without a general anesthetic may be difficult or impossible. In some cases it is easy; usually it is painful. In my own practice I have rarely found the information obtainable by this means valuable enough to make up for the notable pain and discomfort caused by the procedure.

Fig. 221.—Set of Endoscopic Tubes in Box with Chetwood Light.

At whatever point the examination is commenced, successive areas of mucous membrane come into view as the tube is slowly withdrawn. Slender applicators of wood or metal, covered at one end with cotton, are usually necessary to wipe away the excess of lubricant, pus, blood, etc., from the wall of the canal. It is to be borne in mind that the color of the mucous membrane varies in health in different parts of the canal, and is also varied mechanically by the pressure of the endoscopic tube. If the tube is pressed against the urethral wall, the mucosa appears pale; if the pressure ceases, red again. The normal color is, in general, pink or salmon color. The variations in the different portions of the canal in health must be learned by experience.

Pathological Changes in the Urethra as Viewed through the Endoscope.—Changes in color, in the character of the surface, and in the elasticity of the urethra wall may be recognized. Infiltration of the wall of the canal with connective tissue of new formation is readily recognized by the loss of elasticity thus produced. The urethra does not collapse immediately upon the end of the tube as it is withdrawn, but forms a rather deep, more or less irregular funnel; the surface is pale, sometimes glistening white. When actual stricture exists, too narrow for the passage of the tube, the face of the stricture may be studied. If very narrow, the canal through the stricture may sometimes be identified, and the passage of a filiform bougie thus facilitated. In cases of diffuse infiltration, with loss of elasticity, the entire mucosa will be paler than normal, and the urethra will hug the tube quite firmly, transmitting a leathery sensation to the hand.

Color Changes.—It cannot be said that color changes, in themselves, are of great diagnostic value. The mucous membrane in cases of chronic urethritis may be uniformly reddened, or congested patches or streaks may be visible. As stated, cicatricial areas are white; such may involve the entire caliber of the urethra, or be arranged in plaques or longitudinal streaks. A granular appearance of the mucosa is one of the regular changes seen in chronic urethritis; such areas bleed readily, indicating the presence of an increased number of capillaries. In some cases the reddened mouths of inflamed lacunæ may be visible as minute shallow pits. They are most often seen in the central part of the urethra, and along the dorsal surface; from them a minute drop of pus may sometimes be seen to exude. A deep pit or fold of unusual size—the lacuna magna—is frequently present in the fossa navicularis, near the meatus. Actual erosions, often covered by a soft scab of muco-pus, are a more or less regular lesion of chronic urethritis. Minute elevations of the mucous membrane, looking like translucent granules, are occasionally visible; they are presumably minute retention cysts. The presence of actual ulceration may be visible in chancroid of the urethra, rarely in true chancre. Tuberculous ulcers of the urethra are rare. They are nearly always associated with tuberculous disease of the deeper portions of the genito-urinary tract, and are consequently of no great diagnostic interest. Scars following the operation of internal urethrotomy are seen as white lines along the dorsum of the urethra. They vary in extent according to the length of the incision.

New Growths of the Urethra.—Polypi in the urethra are capable of giving rise to a chronic muco-purulent discharge. They occur in two forms: (1) Papillomata, resembling the acuminate warts of the prepuce and glans. These are usually pedunculated, pale growths, sometimes cauliflowerlike, sometimes filamentous. They occur chiefly in the anterior part of the canal. (2) Mucous polypi. These occur in the deeper parts of the canal as rounded, smooth, bluish-white tumors, somewhat translucent in appearance. They are pedunculated growths, sometimes of considerable size—large enough to fill the orifice of the tube, for example. They are insensitive, soft, and not very vascular. Those situated in the membranous urethra are said to be of firmer consistence and to contain more fibrous tissue.

Personally, I have not found it necessary to use the urethroscope for diagnostic purposes as a routine measure, but only in exceptional cases. It has not seemed to me that for purposes of treatment in chronic urethritis it possessed advantages over other methods in ordinary cases. The traumatism produced by frequent instrumentation is often a distinct disadvantage.

In tumors of the urethra the urethroscope is indispensable both for diagnosis and treatment. In a few cases of intractable chronic anterior urethritis I have found suppurating lacunæ, and have cured the condition by boring into the little pockets with a minute button of nitrate of silver fused on the end of a delicate probe. In the treatment of posterior urethritis I do not believe the use of the endoscope is advantageous.

Inflammation of Cowper's Glands—Cowperitis.—Inflammation of Cowper's glands is a rather uncommon complication of acute and chronic gonorrhea, in the latter case often associated with stricture. In the acute form the gland becomes infected during the later weeks of the disease. The process may end in resolution, or in the formation of an abscess with peri-Cowperitis and more or less extensive suppuration in the perineum. Probably a good many cases of Cowperitis not ending in suppuration pass unnoticed in cases of gonorrhea.

Symptoms of Acute Cowperitis.—The symptoms of acute Cowperitis are pain and tenderness in the perineum. If abscess formation occurs, a tender, circumscribed, rather deep-seated tumor forms to one side of the median raphé, at first hard, later, as the abscess approaches the surface, elastic. Constitutional symptoms may be more or less marked. If not incised, the abscess may rupture into the urethra or discharge by ulceration through the skin of the perineum. Urinary fistula rarely, if ever, follows, though a fistulous communication may sometimes be demonstrated by injecting a colored fluid into the sinus and causing the patient to urinate. The abscess is to be differentiated from ordinary periurethral suppuration chiefly by its lateral position. Both conditions require incision, and in both stricture should be sought for.

Chronic Cowperitis.—Chronic inflammation of Cowper's gland is evidenced objectively by the presence of a more or less tender nodule, or a sense of resistance to one side of the median line in the perineum, and by the presence of a chronic urethral discharge.

Tuberculosis, cysts, and cancer of Cowper's gland have been observed.

Folliculitis.—Any of the glandular crypts of the urethra may be infected in the course of gonorrhea. So long as the duct of the follicle remains open the discharge will escape into the urethra, and will produce no distinctive symptoms. These cases, however, show marked chronicity, and a tendency to relapses and auto-reinfection. When, however, the duct or orifice becomes plugged, retention of the purulent exudate occurs, with the production of a cystlike formation attached to the urethra. So long as the infection remains limited to the follicle itself, the size of the tumor produced rarely exceeds that of a pea. Such may be felt as a shotlike body under the skin, closely connected with the corpus spongiosum. They may be found anywhere along the canal, but certain favorite sites exist—namely, on either side of the frenum, another about two to three inches back of the meatus. The former, if it ruptures or bursts externally, may give rise to a fistula rather difficult to cure. When infection extends outside the wall of the inflamed follicle there is formed a periurethral abscess. Such abscesses in the penile urethra may reach the size of a hazelnut, or even of a walnut. They are painful, tender, and give rise to dysuria. In the bulbous portion they may attain the size of a goose egg, with inflammatory edema of the scrotum and perineum. Dysuria may be marked in these cases, but the occurrence of absolute retention strongly suggests the presence of stricture and urinary infiltration. Such abscesses may rupture

into the urethra, when extravasation may follow. Abscesses arising from the membranous urethra are especially prone to this complication. (See also Abscess of the Prostate.)

STRICTURE OF THE URETHRA

As elsewhere stated, congenital stricture of the urethra is very rare, except just at or within the meatus. The greatest number of urethral strictures are due to two causes: gonorrhea and trauma. The former is the most frequent. Both are cicatrices of the urethral wall, and by contracting tend continually to diminish the caliber of the canal and to produce urinary obstruction. Varied and often very serious symptoms follow, ending in the death of the individual, in many instances, unless relieved by surgical means.

As unusual causes of stricture may be mentioned ulcerative processes of the urethra—i. e., chancre, chancroid, cancer, and tuberculosis.

In the production of gonorrheal strictures it is doubtless the gonorrheal process itself which is responsible for the formation of stricture in most cases. What part may be played by the use of strong injections, by traumatism—as from unwise instrumentation or from breaking a chordee—it is impossible to say. In my belief these causative factors are of trifling importance.

The production of scar tissue in the urethral wall is apparently caused in two ways: (1) By the invasion of the submucous structures by the gonococcus, and the production of small-celled infiltration, eventuating in fibrous tissue of new formation (Finger, Guyon). (2) By the leakage of small quantities of urine through the damaged mucous membrane, and the consequent inflammatory process, leading as before to the production of scar tissue (Harrison).

The extent and depth of such scar tissue varies in different cases, and consequently we find strictures involving in some cases only a very limited area of the canal, forming a sharply bounded ring or bridle, the wall of scar tissue being of slight depth and extending only a short distance beyond the mucous membrane. In other cases the entire thickness of the corpus spongiosum may be involved in the scar for several inches, or even its entire length, so that the urethra is converted into a leathery, tough, inelastic canal, of varying caliber, very narrow at some points, less so at others. The passage through the strictured portion may be tortuous. The urethra behind the strictured portion is more or less dilated.

Strictures may be classified, according to their situation, into anterior strictures—i. e., in front of the peno-scrotal angle—and deep strictures, those situated behind that point. Clinically this is a distinction of some importance, since the latter group, when cut, demand an additional perineal incision for proper and safe drainage. Strictures are sometimes classified, according to their caliber, into strictures of large and small caliber, those not admitting a No. 15 French instrument being included in the latter group.

Certain marked clinical differences between traumatic and gonorrheal stric-

tures exist. The former are most common in the bulbous and membranous portions. The latter may be anywhere in the canal except in the prostatic portion, where very few examples have been described. *Tight* gonorrheal strictures are also most frequent at or near the bulbo-membranous junction. Traumatic strictures produce symptoms very soon after the injury in a very large proportion of cases, only rarely after a long interval. A tight traumatic stricture may develop in a few weeks. They nearly always require a cutting operation for their relief, and always recur unless kept open by the passage of sounds or unless the scar tissue is excised and the divided ends of the urethra be united by sutures, and in most cases even after this operation. Gonorrheal strictures do not often produce marked symptoms for a year or more, in many cases only after a period of years. They may often be relieved in a satisfactory manner by dilatation, in a few cases even cured. Those in the penile urethra may usually be cured by internal urethrotomy. A certain small proportion, also, of strictures situated at the bulbo-membranous junction may be cured by thorough division with a knife. Traumatic strictures are, from the mode of their production, usually single. Gonorrheal strictures are usually multiple.

Situation.—The conclusions of different observers vary on this point. Otis, who took cognizance of slight differences in the caliber of the canal, found the majority of strictures in the anterior urethra. Sir Henry Thompson, whose observations were extensive and accurate and are still much quoted, found the bulbo-membranous junction the most frequent site.

The statistics of Thompson, based upon the study of 270 specimens, were as follows:

He divided the urethra into three regions: (1) The bulbo-membranous, including 1 inch in front of and ¾ inch behind the junction of the spongy with the membranous urethra. (2) From the anterior limit of region 1 to within 2½ inches of the meatus, embracing from 2½ to 3 inches of the spongy urethra. (3) The first 2½ inches of the canal from the meatus.

The 270 preparations showed 320 strictures:

Region 1 contained 215 strictures = 67 per cent.
Region 2 contained 51 strictures = 16 per cent.
Region 3 contained 54 strictures = 17 per cent.

There were 185 cases of one stricture only, situated in region 1. There were 17 cases of one stricture only, situated in region 2. There were 24 cases of one stricture only, situated in region 3.

The observations of Otis—who, as stated, recognized points of diminished urethral caliber much slighter in extent than did Thompson, and regarded such narrowings as of pathological significance—found the relative frequency of strictures in different parts of the canal to be as follows: (1) It will be found that out of 258 strictures 52 were in the first quarter inch of the urethra; 63 in the following inch, viz., from ¼ to 1¼; 48 from 1¼ to 2¼; 48 from 2¼ to 3¼; 19 from 3¼ to 4¼; 14 from 4¼ to 5¼; 8 from 5¼ to 6¼; 6 from 6¼ to 7¼.

By the above statement it will be seen that they occur, as would naturally be expected, in greater frequency where the inflammation begins the earliest and

rages the hottest, and gradually diminish in frequency in the deeper portions of the canal.

Those who are particularly interested in this topic are referred to "Stricture of the Male Urethra, Its Radical Cure," by F. N. Otis, M. D. G. P. Putnam's Sons, 1885. In this work the question of the caliber of the urethra and of the situation of urethral strictures is very fully discussed. Not only the views of Otis, but also those of Henry B. Sands, Robert F. Weir, and others are given.

At the present time most American surgeons believe that Otis's ideas about the distensibility of the normal urethra were in the main correct, and that the rule he formulated in regard to the nearly constant relation between the circumference of the flaccid penis and the caliber of the urethra was a good, practical working rule. That Otis attributed too much importance to slight contractions of the urethra I think there can be no question, especially in regard to the importance of such contractions in the prolongation of chronic urethral inflammations. Personally I do not find nearly so many strictures of large caliber requiring operation as I did fifteen or twenty years ago, nor do I believe that such contractions are the sole or most important cause for the continuance of chronic urethral discharges. The persistence of the gonococcus in the anterior and posterior urethra, in the prostate, and in the seminal vesicles seems fully to account for the chronicity of the disease in a large proportion of cases; not but that stricture is responsible for gleet in many instances, and that division of strictures often is followed by the cessation of anterior urethritis. It is always a question, however, how much influence is to be attributed to the operative removal of the stricture and how much to the systematic passage of full-sized sounds upon the diseased mucous membrane, a very valuable curative measure in itself.

In reference to the situation of strictures, it may be said that tight strictures are certainly most frequent at or near the bulbo-membranous junction, those of large caliber in the penile urethra.

Symptoms and Diagnosis of Stricture of the Urethra.—The usual symptoms of stricture of the urethra are a persistent urethral discharge, pyuria, changes in the size, shape, and force of the urinary stream; frequent, often painful, urination; dribbling at the end of the act, and in advanced cases retention of urine. Notable exceptions, however, occur, in that an individual may have a rather tight stricture for years without being conscious of it. The first symptom to attract the attention of a nonobservant person may be retention of urine. The time elapsing after gonorrhea before a stricture gives symptoms varies from one to twenty years or more, nor does the time seem to depend upon the duration or intensity of the gonorrheal process.

The Symptoms in Detail.—*Chronic Urethral Discharge or Gleet and Pyuria.*—In some cases the discharge persists after a gonorrhea indefinitely. It is usually small in amount, merely a drop of muco-purulent material found on separating the lips of the glued meatus in the morning—"*goutte militaire*, good-morning drop, gleet." In addition the urine contains shreds, or, if pos-

terior urethritis coexists, may be from time to time clouded with pus. Slight causes of irritation, alcohol, coitus, fatigue, exposure to cold and wet are apt to cause an increase in the amount of discharge and an aggravation of all the symptoms. These patients often believe that each exacerbation following coitus is a new infection. In other cases the patient apparently recovers from his gonorrhea. He has no discharge. His urine may even be quite free from pus. After several years, following some exciting cause such as excessive coitus, a gleety discharge reappears, and *usually continues indefinitely until the stricture is cut or dilated.* In a few cases only, notably of deep-seated, tight stricture, there is no urethral discharge. In these cases pus and shreds in the urine are present from the coexistent posterior urethritis.

Changes in the Urinary Stream.—Until a stricture has contracted to rather a narrow caliber, no changes are observed in the urinary stream. At most the patient may notice that it takes him longer to empty his bladder, and that the stream is projected with less force. Narrow strictures near the meatus may cause the stream to be twisted, forked, or bent, and yet it must be remembered that the stream may possess these characters when no stricture exists. The *coup de piston* at the end of urination is interfered with, owing to the loss of elasticity of the urethral wall. He may dribble after he has finished, or find that he wets his garments after replacing the penis in his clothing. *Deep-seated strictures do not produce changes in the shape of the stream.* The patient observes that his bladder is emptied slowly and with more effort than formerly. The stream gradually diminishes in size. There is dribbling at the end of urination.

Pain and Frequency of Urination.—Pain may be felt independently of and during urination. Erections are sometimes painful, from the loss of elasticity of the corpus spongiosum. Painful ejaculation is common from mechanical interference with the passage of semen through the stricture. In extreme cases only a little semen appears at the meatus; the remainder goes back into the bladder, or escapes slowly from the meatus as the erection subsides. Spontaneous sharp or aching pain is often felt in the sacrum, perineum, glans penis, urethra, testes, and cords, sometimes in the thighs. Painful and frequent urination is usually due to posterior urethritis. As the stricture contracts the symptoms grow slowly and progressively worse. In certain cases a generalized cystitis develops, with increased severity of symptoms. The urine may remain acid. Ammoniacal decomposition is less common than in insufficient bladders from prostatic obstruction. In certain cases interstitial cystitis produces cicatricial atrophy of the bladder. Increased pain and frequency result. The capacity of the bladder may be reduced to an ounce or two. These patients must urinate very often; some of them suffer from almost constant dribbling.

Frequent urination is a very constant symptom of stricture. At first it may be slight, but as time goes on the patient is obliged to urinate every hour or two in the daytime, and to rise several times at night.

Sexual Symptoms.—Erections may be painful and ejaculation may be interfered with. In some cases resultant prostatic inflammation is attended by irritation of the sexual sphere. These patients have frequent erections, commit sexual excesses, and may have painful nocturnal emissions. In other cases hypochondriacal symptoms are marked, with sexual neurasthenia. There may be psychical impotence. In some cases imperfect erections, premature ejaculation, and other neurasthenic symptoms are present.

Retention of Urine.—One of the grave accidents regularly associated with tight stricture of the urethra is retention of urine. While in the majority of cases the patients have long been conscious of the presence of stricture, in others the early symptoms have not attracted attention. After indulgence in alcohol, coitus, exposure to cold and wet, etc., the urethral mucous membrane at and behind the stricture becomes congested and swollen, the stricture closes, and suddenly the patient finds himself unable to urinate. Under suitable treatment the swelling may subside after some hours and the patient may empty his bladder, or he may be relieved by catheterization and have no further attack for many months. In other cases the bladder becomes greatly distended, and may even rupture from slight trauma; usually, sooner or later, a little urine passes the stricture, and dribbling from overflow—*ischuria paradoxa*—is the result. Permanent damage to the bladder with atony may follow, though less common than in retention from enlarged prostate. (See also Bladder.)

Sequelæ of Stricture.—*The bladder and kidney complications* resulting from gonorrhea and stricture are described elsewhere. Septicemia, pyemia, and uremia may occur, the first two at any time during the course of the disease, often as the result of instrumentation or of operation when perineal drainage is omitted; the third as the result of retention, usually in neglected cases where the kidneys are already damaged, sometimes as the result of instrumentation or operation.

Among other sequelæ of stricture may be mentioned, in addition, vesical calculus, epididymitis and sterility, seminal vesiculitis, hemorrhoids, hernia, urinary infiltration, and fistula. (See sections on these topics.)

Conditions Resulting from Maltreatment and Neglect of Stricture.—Certain grave conditions may result from the maltreatment and neglect of stricture of the urethra. They are false passage, periurethral infection and gangrene, infiltration of urine, urethral chill and fever, pyemia, septicemia, and urinary fistula.

False Passage.—When an instrument is forced through the urethral wall into the surrounding tissues, the injury is known as a false passage. The instrument usually perforates the floor of the urethra, very rarely the roof. The urethral wall gives way at the site of a dilated follicle, an ulcerated area, or enters a small abscess cavity, or in some cases perforates the wall of the canal just in front of the stricture. In the last instance the injury is due to forcible attempts to pass a catheter or a solid instrument through the stricture. In careful hands, and with proper instruments, a false passage should be a rare accident. The creation of a false passage may be recognized from the following signs: The instrument may pass onward, but may be seen and felt to

deviate from the middle line. The beak of the instrument is fixed—i. e., it cannot be rotated freely, as is the case when it has entered the bladder. The instrument is not grasped and held as is the case when engaged in a stricture, unless, perchance, it has been forced through a mass of tough scar tissue. If a silver catheter has been used, no urine flows. A finger introduced into the rectum will discover the beak of the instrument, not in the bladder but to one or other side of the median line, and usually to one or other side of the prostate, if it has advanced so far. The withdrawal of the instrument is followed by bleeding from the urethra. The creation of a false passage is often followed by septic symptoms—i. e., a chill and a rise of temperature. A bloody discharge from the urethra is followed by a purulent one, lasting for a number of days. If the patient is able to urinate, no instrument should be introduced for ten days or longer. If not, and it is imperative to get into the bladder, a metal catheter may be very gently introduced, and made to hug the roof of the canal throughout its passage; sometimes the false route may be thus avoided. The urethra may be filled with filiforms, one of which may finally engage in the stricture, and this may be used as a guide for a tunneled catheter or as a guide for a Maisonneuve urethrotome, or as a guide for a perineal section. If no instrument can be made to pass, a metal instrument may be introduced as far as the stricture, and the urethra opened upon it in front of the stricture and the true passage sought for. If the orifice of the stricture cannot be found, a slender, straight knife may be thrust into the mass of scar tissue, exactly in the middle line, and the urethra opened behind the stricture. The left forefinger in the rectum aids the surgeon in establishing the proper direction of the cut. It is seldom that a surgeon of skill and experience finds this procedure necessary. Some surgeons prefer to open the bladder above the pubes and perform retrocatheterization.

A false passage may be followed by a perineal abscess; urinary infiltration is quite unusual. If instrumentation is commenced too soon, a false passage may be reopened, and continue as a suppurating tract for an indefinite time.

Urethral Shock—Urethral Chill and Fever—Urethral Sepsis and Pyemia.—In many cases of urethral stricture the introduction of an instrument through the stricture and into the bladder, even when done skillfully and gently and with all due aseptic precautions, may be followed by a series of phenomena usually spoken of as *urethral chill or urethral fever.* This is notably true of cases where the urethra is dilated behind a tight stricture, where chronic anterior and posterior urethritis, as well as cystitis, are present; in other words, where there is chronic pyogenic infection of the lower genito-urinary tract. In a large proportion of cases the phenomena are simply those of urethral sepsis of a more or less serious character; in others there exists a nervous reflex element acting upon the functions of damaged kidneys and eventuating in uremia; in others sepsis and uremia are combined. Whether in any of the cases the symptoms arise from a purely nervous reflex, I am not prepared to say. Certain it is that the introduction of a clean instrument into

a healthy genito-urinary tract is very rarely followed by any serious disturbance. The cases may be divided into several groups:

1. *Urethral Shock.*—We differentiate urethral chill and fever from the purely nervous disturbances, usually of no serious moment, which may follow the introduction of an instrument into the urethra and bladder of a highly neurotic individual. The patient is very nervous and apprehensive; the introduction of an instrument into his urethra is attended by much suffering; as the beak passes through the prostatic portion he may scream with pain. His face becomes pale and bathed in a clammy sweat, his extremities cold, his pulse feeble; he may faint; his teeth may chatter and his body tremble. He may feel nauseated, and even vomit. After a few minutes' rest in the recumbent posture, perhaps after a drink of whisky, he is himself again. There is no elevation of temperature. As he recovers his face may redden, he may perspire freely. So long as he has a healthy genito-urinary tract and the instrument was clean, no further symptoms follow. These phenomena are often spoken of as urethral shock.

2. *Urethral Chill, Urethral Fever, Urethral Sepsis.*—The phenomena of urethral fever follow the introduction of instruments into and operative procedures upon the urethra, the prostate, and the urinary bladder, usually in the presence of pyogenic infection of the genito-urinary tract, occasionally as the result of the introduction of infective organisms during the instrumentation. Several significant and interesting facts are to be borne in mind: The symptoms occur with much greater frequency in the presence of an obstructive lesion, stricture of the urethra, enlarged prostate, or of an insufficient bladder than under other conditions; that is to say, in cases where the drainage of the lower genito-urinary tract is imperfect. This fact is well illustrated by the following observation, often made: A patient with a stricture of the urethra has a chill and fever nearly every time a sound is introduced. The stricture is cut and perineal drainage instituted. Following the operation and subsequent instrumentation neither chill nor serious febrile disturbance occur. Such cases are best treated by free division of all strictures, with perineal drainage, not by dilatation.

Other observations are of interest: Following instrumentation or operative measures upon the dependent—i. e., penile—portion of the urethra, urethral chill and fever are extremely rare. The frequency of these accidents increases the farther back the operative procedure extends. They are notably frequent as the result of instrumentation of the prostatic urethra, a part peculiarly susceptible to pyogenic infection, and well fitted for the absorption of toxic products. Formerly, when deep strictures of the urethra—i. e., those from five to five and a half inches from the meatus—were commonly treated by internal urethrotomy alone, septic symptoms of a serious, even of a fatal, character were not rare accidents. At present the uniform practice of draining such cases through a perineal incision has rendered these complications infrequent. The practice, formerly common, of treating strictures by divulsion or by

rapid dilatation was often followed by urethral sepsis. The lacerated wounds thus caused here, as elsewhere, formed ideal avenues for septic absorption.

Some peculiarities are observed in regard to urethral fever following catheterism, probably explicable on the ground of the varying virulence of the microbes present in the individual case and of the varying resistance of the same individual at different times. In some cases serious symptoms follow the first introduction of a sound through a stricture; such may even be fatal. In other cases the chills, fever, etc., will follow the introduction of an instrument at irregular intervals, though the character of the instrumentation and the condition of the urine may seem to be identical on each occasion. Slight traumatisms may be followed by severe symptoms, gross violence by none.

Several conclusions may be drawn from the results of experience: Catheterism is to be regarded as a serious procedure (1) when it is done for the first time; (2) when obstructive lesions of the lower urinary passages are present; (3) when there is old or recent pyogenic infection anywhere in the genito-urinary tract, but especially in the urethra, prostate, and bladder; (4) in the presence of any form of nephritis.

Precautions to be Used in Catheterism.—Catheterism should be surrounded by every safeguard for the prevention of infection. One of the best of these is antiseptic irrigation of the bladder as soon as the operation is finished. The best procedure, in my opinion, is that of Ultzmann—i. e., the introduction into the bladder through a catheter of 8 or 10 ounces of a warm antiseptic solution (potassium-permanganate solution, 1–1,000–2,000, or of nitrate-of-silver solution, 1–1,500–4,000)—after which the patient rises and empties his bladder, thus thoroughly washing out the bladder and urethra. If the bladder is insufficient, the patient voids as much as he can; the remainder is removed by catheter.

The *use of urotropin* internally, in doses of 0.5 to 1.0 three times daily, is believed by many surgeons to diminish the likelihood of urethral fever.

Instrumentation should be performed with the utmost gentleness. Other things being equal, the greater the trauma to the mucous membrane the greater the likelihood of septic absorption. In prostatic cases, when catheterized for the first time, and in other cases known to be subject to urethral chills, the patient should remain quietly in bed for six hours after catheterization.

The following medication, it has seemed to me, tends to prevent the occurrence of urethral chill, or to ameliorate the discomfort in the less serious cases when a chill does occur. It may be given at the time the instrument is passed:

Morphina muriate	$\frac{1}{6}$ grain.
Extract cannabis indica	$\frac{1}{4}$ "
Nitroglycerin	$\frac{1}{500}$ "
Extract of hyoscyamus	$\frac{1}{2}$ "
Oleo resin of capsicum	$\frac{1}{10}$ minim.
Oil of peppermint	$\frac{1}{10}$ "

Mix and make into one pill.

Symptoms of Urethral Chill, Urethral Fever, Septic Intoxication of Urethral Origin.—The symptoms of acute but transient sepsis following the introduction of a sound into the bladder were very well described by Sir Henry Thompson. The description is here quoted:

Some three or four hours afterwards the patient wants to pass water, and feels, in doing so, a smarting sensation which, after all, is the natural consequence of passing any instrument through the urethra whether healthy or diseased. Soon after, it may be a few minutes or an hour, or even more, the patient suddenly feels a cold chill through his back, thence invading the whole system, so that his teeth chatter involuntarily and all his limbs tremble so much that it is obvious to a bystander that he is the subject of a convulsive shudder which he cannot control, affecting the voluntary muscles. The patient's look is haggard; he becomes grayish in tint, dark beneath the eyes, the expression of his face is altered, his breathing is hurried and the voice changed. The attack varies greatly in intensity in different cases and circumstances. Such a patient is, of course, sent to bed at once, if not already occupying one, that hot bottles and warm coverings may be applied; and the bed itself shakes with the rigor, if the fit is severe. He now begins to complain of severe pains in his head, back, and limbs; there may be an attack of vomiting or of purging, although these are not so common. The temperature if taken now is high, and rising rapidly, reaches nearly 104° F. or passes it, sometimes to 105° F. In half an hour, perhaps, more commonly an hour or more, the pale and contracted features become red, then flushed; the mouth is dry; he asks for a drink, and with an oppressive sense of heat he is eager to throw off the coverings which have been heaped upon him. His pains are now severe and his temperature at its maximum; the pulse is rapid, hard, and vibrating. There gradually appears a little glistening in the dry, cutaneous surface, the commencing dew of gentle perspiration which quickly becomes profuse from the now soft, relaxed, and reddened skin, with sensible relief to pain and feverish heat. The respiration becomes slower and fuller and the patient is tranquil, passive, exhausted in appearance as he lies on his back sweating at every pore. Then the pulse slowly grows less rapid, is soft and full; temperature diminishes, thirst continues, and he passes a little urine dark in tint. After six, twelve, or eighteen hours the signs of fever disappear, leaving him more or less weak, and he is convalescent the next day or the following one.[1]

This is the history of a typical attack. In other cases the symptoms begin in much the same way, but the patients go on to suffer from acute or chronic septicemia or from pyemia, not differing from these conditions from other causes except that combinations with acute or chronic uremia are frequent. The diagnosis is usually simple. (See Septicemia and Pyemia.)

Uremia and Combinations of Sepsis with Uremia.—One of the gravest accidents following the passage of a sound through a stricture or catheterization in prostatic obstruction is suppression of urine and death from uremia. Cases have been reported in which death occurred within twenty-four hours from the first passage of an instrument. It would seem probable that in these the cause

[1] Sir Henry Thompson, "Diseases of the Urinary Organs," 1888, p. 180.

of death has been a very intense sepsis in the presence of nephritis, the latter often unsuspected. No case of ordinary suppression of urine is fatal in twenty-four hours from its inception, and if death in these cases is attributed to uremia alone, it must, I think, be assumed that a marked uremic intoxication existed at the time the urethra was explored.

More common than these sudden and acute cases are those of subacute sepsis and chronic uremia, following instrumentation or operation upon cases of stricture of the urethra, enlarged prostate, or other obstructive lesion. These are seen not infrequently in old and neglected cases of stricture and in prostatic obstruction. The kidney lesion is sometimes a chronic interstitial nephritis, sometimes chronic diffuse nephritis of other types, in other cases a septic ascending or hematogenous infection of the kidney; and since in this group of kidney infections the lesion is usually bilateral, a fatal result is to be expected in a very large proportion of cases. (See Kidney.)

These patients, after the passage of a sound, catheterization, or some operative procedure on the lower genito-urinary tract, develop, sometimes suddenly, sometimes gradually, the symptoms of a moderately severe general sepsis. In addition, the quantity of urine is diminished, the excretion of urea is below normal; the urine contains albumin and casts, pus in greater or less amount, bacteria of various kinds, sometimes blood. As the days go by the patient becomes more and more stupid and apathetic. The fever is usually moderate and of the ordinary irregular septic type. Gradually these patients sink into a condition of exhaustion and die; or uremic coma may come on at any time, with total suppression of urine, ending in death after several days.

The pyemic cases run the course of an acute or chronic pyemia, as elsewhere described.

Phlegmonous Inflammation and Gangrene of the Genitals, of Urethral Origin, with or without Urinary Infiltration.—During the course of stricture of the urethra, notably in cases of tight perineal stricture with or without retention of urine, and in debilitated subjects, septic and putrid infection of the periurethral tissues may suddenly occur, spread rapidly, and cause death in a few days. The condition is frequently accompanied by urinary extravasation, and yet it is to be borne in mind that the escape of urine into the tissue is merely a concomitant, not an essential, part of the process.

It was formerly believed that, as the result of straining, the muscular contractions of the bladder ruptured the dilated urethra behind the stricture, and forced the urine into the surrounding tissues under considerable pressure. This theory is not consonant with known facts. Retention of urine and a dilated bladder is not followed by powerful contractions of the detrusor muscles. Phlegmonous inflammation and gangrene may occur without retention, and in cases of stricture of large caliber. The essential factor is an ulcerative, suppurative, or gangrenous process of the urethral wall, with consequent infection of the periurethral structures. Urine may or may not be found in the infected tissues at operation or autopsy.

The symptoms and history vary somewhat in different cases. Usually these patients have long been afflicted with stricture; they are often debilitated alcoholic subjects. There may be a dilated and pouched urethra behind the stricture. A periurethral abscess, acute or chronic, or gangrene of the urethral wall often precedes the progressive infection. In some cases the infection of the periurethral structures is accompanied by retention of urine, in some it is not. The general symptoms consist of rapidly progressive and profound physical and mental depression. There is a rapid, feeble pulse, an elevated or subnormal temperature, usually stupor or apathy, followed by quiet or active delirium, coma, and death. Locally, a tender, boggy, edematous swelling rapidly forms in the perineum, extends forward, involving the scrotum and penis, later the inguinal regions and the anterior abdominal wall. The attachments of the deep layer of the superficial fascia usually serves as a bar to the involvement of the thighs and gluteal region. The entire urethra may slough, together with the contents of the ischiorectal fossa; occasionally perforation occurs into the rectum. The process does not extend above the pelvic diaphragm, nor is the bladder itself involved. Every hour the patient sinks deeper and deeper under the overwhelming septic intoxication or sapremia. The scrotum swells to enormous size, and may reach the proportions of a large grape fruit in twenty-four hours. The integument and loose tissues of the penis also swell greatly. If the process be of the gangrenous type, a brown, then green, then greenish-black discoloration appears on the surface, and within a day or two the skin of the external genitals, perineum, and lower abdomen may be totally gangrenous. In the cases not associated with putrefaction, inflammatory edema takes the place of gangrene. If the patient survives long enough the skin sloughs here and there; pus, urine, and masses of necrotic tissue are discharged through the openings thus formed. Incision of the infected tissues opens up cavities filled with thin pus and urine. The subcutaneous tissues are found in a condition of porky edema, or gangrenous or sloughing, according to the duration and character of the process. A communication with the urethra

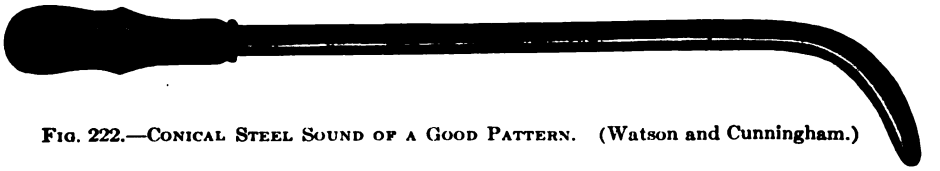


FIG. 222.—CONICAL STEEL SOUND OF A GOOD PATTERN. (Watson and Cunningham.)

may or may not be found. Urine may or may not be extravasated. A tight, sometimes impermeable, stricture is usually present, and perineal section, often without a guide, is necessary to drain the bladder. Retention of urine is the rule. A small proportion of these cases are saved by early and extensive incisions. From what has preceded, it may be understood that the condition is one not likely to be confounded with any other. There is a history of an old and neglected stricture, usually retention of urine, profound septic symptoms, and the characteristic local lesions.

I was once called to operate upon a case of supposed urinary infiltration. I found a man who had, indeed, retention of urine from a tight stricture. His scrotum was enormously swollen; but the swelling was ovoid, limited to one half the scrotum, sharply circumscribed, neither tender nor painful, had been present for some time, and was translucent—in other words, a hydrocele.

Diagnosis of Stricture of the Urethra and the Detection of Stricture by Instrumentation.—The symptoms of stricture of the urethra have already been described. Some additional diagnostic data are here given.

Chronic urethral discharge is often due to stricture, though not, as was taught and believed by Otis, invariably. Not every prostitute has a contagious

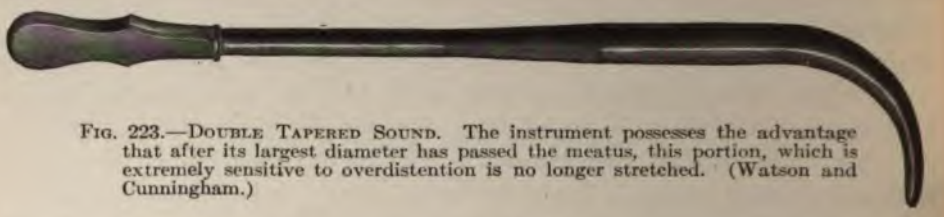


FIG. 223.—DOUBLE TAPERED SOUND. The instrument possesses the advantage that after its largest diameter has passed the meatus, this portion, which is extremely sensitive to overdistention is no longer stretched. (Watson and Cunningham.)

gonorrhea, and a man who acquires a fresh discharge every time he copulates very probably has a stricture. When the stricture is removed he may get well, not before. Slight narrowings of the urethra are not necessarily pathological. A man who takes a 30 French sound smoothly and easily, so that the instrument is nowhere grasped and more or less firmly held, does not require a cutting operation, though one part of his urethra may easily be stretched to 40 and another only to 30. The commonest point of physiological narrowing in the urethra is the meatus urinarius, or in the next half inch of the canal. If markedly contracted, such a meatus may cause the persistence of a urethral discharge, and will certainly prevent the passage of a full-sized sound, *one of the most valuable means of treating chronic anterior urethritis*, whether due to stricture or not. Thus, in certain cases the division of such a meatus up to a

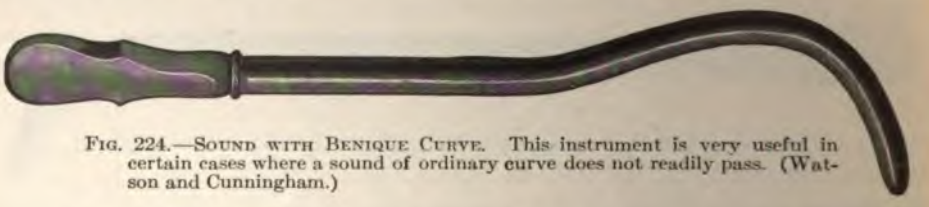


FIG. 224.—SOUND WITH BENIQUE CURVE. This instrument is very useful in certain cases where a sound of ordinary curve does not readily pass. (Watson and Cunningham.)

reasonable size—i. e., somewhere short of hypospadias—may be a valuable curative measure.

It often happens that a patient presents himself with symptoms of a probable stricture. A sound passes as far as the bulbo-membranous junction, and is there arrested. The surgeon should not decide too hastily that the patient has a tight stricture at that point. It may be only the resistance offered by spasm of the compressor urethræ muscle, to be overcome by patient and very

gentle pressure; or the beak of the instrument may have caught against the triangular ligament, owing to a dilated bulbous portion, and must be lifted over the ligamentous wall before it will enter the membranous portion of the urethra. Sometimes a large instrument will pass this point with ease, while a small one will catch every time. If an instrument of the ordinary curve cannot be made to pass, a sound with the Beniqué curve will sometimes enter with ease.

When a patient presents himself with a perfectly definite history of stricture, such that the surgeon decides upon operative treatment, and more especially if the patient gives a history of urethral chills and fever following former instrumentation, it will be safer to make the exact diagnosis of the situation and size of the stricture while the patient is under a general anesthetic, and to operate then and there.

Free and complete division of the scar tissue constituting a stricture offers the best and usually the only hope of permanent cure. A partially divided

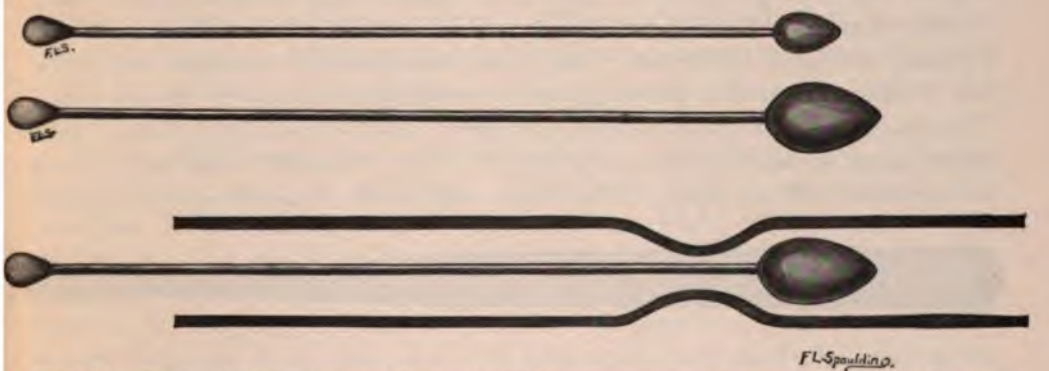


FIG. 225.—BOUGIES À BOULE FOR THE DETECTION OF STRICTURE OF THE URETHRA. Below is a diagram showing the relations of the shoulder of the instrument to the posterior face of a stricture. (Watson and Cunningham.)

stricture recontracts at once, and the patient is but little better off than though no operation had been done. The surgeon may know that the stricture is completely severed from the fact that, when the Otis urethrotome is used, the instrument may be turned up several sizes larger without resistance on the part of the tissues. Further, a full-sized sound may be introduced readily into the bladder, and will no longer be gripped by the urethral wall. If this result cannot be attained the stricture will require the passage of sounds at regular intervals, probably for the remainder of the patient's life. When the entire urethra is converted into a leathery, inelastic tube, no operation can effect a cure. Strictures of the penile urethra can usually be cured by urethrotomy; tight strictures at or near the bulbo-membranous junction, only rarely. When, after operation, a stricture is going to recontract, the surgeon can readily detect such a tendency within a month, if not before the end of that period.

Instruments Useful in the Diagnosis of Stricture of the Urethra.—The instruments useful in the diagnosis of stricture of the urethra are a set of conical steel sounds, sizes 10 to 40 French; a few steel sounds with the Beniqué curve, the medium sizes, 18 to 30 French. For the detection of stricture some surgeons prefer blunt sounds—i. e., of the same size to the point of the beak. Conical sounds made with a double taper possess the advantage that the meatus is not distended when the beak has passed into the deeper portions of the canal. Extreme distention of the meatus is very painful.

A set of bulbous bougies (*Bougies-à-boule*), made with a rather abrupt shoulder, sizes 5 to 40 French. These may be of steel or of woven material.

A set of olive-tipped silk bougies, best weighted with fine shot; sizes, from the smallest made up to 20 French.

Filiforms, both silk and whalebone.

An Otis urethrometer.

A metal scale plate, giving the English and French diameters; one straight edge of this plate graduated in inches, the opposite one in centimeters.

The best soft instruments—namely, those made of woven silk, coated with varnish—are made in France. They will stand moderate boiling a few times, but if often boiled they become rough or cracked, and must be thrown away. The shoulders of bulbous bougies should be made quite abrupt, since these give a more decided jump when pushed or drawn through a stricture. Those of varnished silk are more flexible than those made of metal, and the former

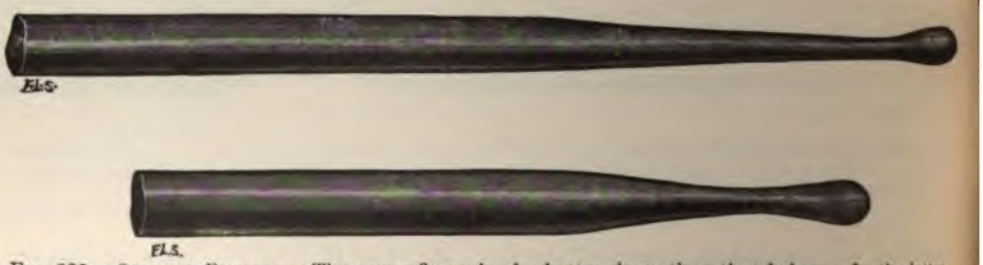


Fig. 226.—Olivary Bougies. The upper figure is of a better shape than that below. In the latter, the tip is too blunt and the part behind the tip increases too rapidly in size. (Watson and Cunningham.)

are less likely to injure the urethra; on the other hand, they are soon destroyed by boiling.

Whalebone filiforms are very useful in finding the channel through a narrow stricture. They have a rounded tip, and are tapered for an inch or two up to the full size of the shaft. They are usually about three millimeters in diameter. They are made in two lengths—one foot and two feet. The latter are valuable as guides, when threaded through the tip of a so-called tunneled sound. It is of advantage to have the extreme tips of some of the filiforms bent into a curve, or twisted into a spiral, or angulated; this can be accomplished by dipping the tip in hot water, when it may be bent into any desired shape. One or other of these forms may be made to engage in the channel

of a tight stricture. When using filiforms, their passage is facilitated by filling the urethra with warm oil. If the instrument catches in a fold of mucous membrane, a pocket, a false passage, or against the face of the stricture, it should be withdrawn a little, rotated, and again advanced during the rotation. A very useful measure is to fill the urethra with whalebone filiforms, seeking to advance first one and then another. Some of them will stick at different levels, engaging in the lacunæ, pockets, etc., and finally one will engage in the stricture itself, and may be pushed on into the bladder. "Patience, perseverance, and sweet oil," as the proverb says, will accomplish much. There are very few strictures so tight and so tortuous that they cannot finally be passed in this manner. When, after patient effort, the surgeon succeeds in getting a filiform through a bad stricture, let him leave it *in situ* until he operates. He may thus save himself much time. The orifice of a stricture may also be located through the endoscope.

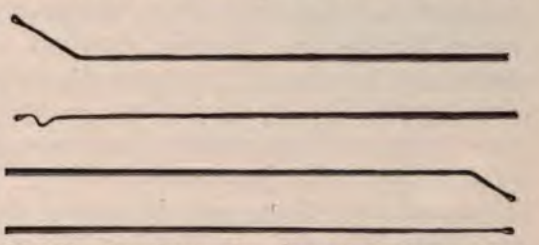


FIG. 227.—WHALEBONE FILIFORMS, BENT AT THEIR TIPS INTO SEVERAL SHAPES FOR ENGAGEMENT IN NARROW AND TORTUOUS STRICTURES. (Watson and Cunningham.)

Woven silk bougies are useful in examining and treating deep strictures of a caliber up to 15 to 20 French. When using metal instruments of a size less than 15 French, the risk of wounding the urethra, when the stricture is at or near the bulbo-membranous junction, is considerable. As elsewhere stated, the shaft and handle of a curved sound form the long arm of a lever held by the surgeon, and force applied here is greatly magnified in the beak constituting the short arm, and this may readily be made to damage the urethra and create a false passage. If slender steel instruments are used at all, this fact must be borne in mind, and extreme gentleness only is permissible in their manipulation. The urethrometer of Otis is a very valuable instrument for the detection of strictures of large caliber in the anterior urethra. It consists of a slender straight steel shaft, at one end of which is a fusiform enlargement covered with a thin rubber cap. This bulbous portion may be enlarged to any desired extent by turning a milled head on the handle. A dial and indicator show to what size the instrument is expanded. The shaft is graduated in inches and half inches, so that the distance of the stricture from the meatus can be seen at a glance. When closed, the bulb measures 16 French. It may be expanded to 45 French. It possesses the advantages that it may be introduced through a narrow meatus, and that with it the entire length of the anterior urethra may be calibrated in a few moments. Its

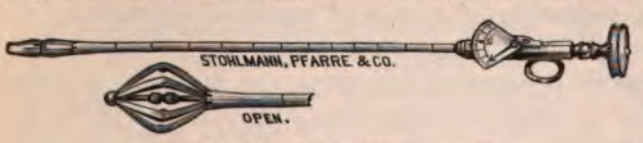


FIG. 228.—THE OTIS URETHROMETER.

disadvantages are that the rubber covering of the expanding portion cannot be made very smooth, so that it tends to catch in the urethra, and may in careless hands give the impression of a decided narrowing where none exists. It is also more irritating than a metal or silk instrument. The method of its use is as follows: The instrument is introduced through the meatus closed, and is passed as far as the bulbo-membranous junction. It is not intended to be passed through the triangular ligament. The bulb is screwed up until the patient has a sense of fullness in the perineum. This indicates that the normal distensibility of the bulbous urethra has been reached. It will rarely vary much, when no stricture is present at that point, from the size formulated by Otis. The instrument is then slowly withdrawn; when an obstruction is reached the bulbous part is screwed down until it passes, again enlarged, and drawn forward. In this way the caliber of the entire anterior urethra may be measured and points of stricture located. The following facts should be borne in mind: (1) The bulbous portion is usually wider than the remainder of the canal, or at least more distensible. (2) A decided narrowing is often present at the peno-scrotal angle, 3 to 3½ inches from the meatus. (3) The meatus is usually narrower than any other part of the canal.

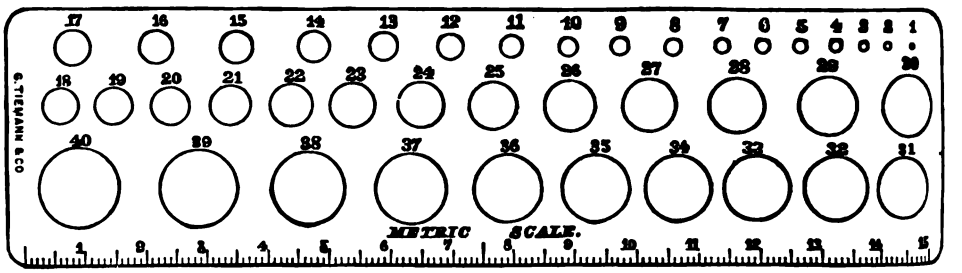


FIG. 229.—SCALE PLATE FOR DETERMINING THE SIZE OF URETHRAL INSTRUMENTS. This is the French scale, the one in common use. The others are superfluous. (Watson and Cunningham.)

When beginning the examination of a case of supposed stricture of the urethra, several preliminary data are sought for. If the patient has a posterior urethritis, such that both portions of his urine are purulent, a sound introduced into his bladder is likely to make him much worse. If he has had former attacks of epididymitis, as evidenced by a firm nodule or a firm thickening palpable in the lower part of the epididymis, the introduction of a sound into the bladder may be the exciting cause of another attack.

Palpation of the urethra sometimes permits one to feel that the urethra is no longer a soft, elastic tube, but has become hard and leathery, sometimes uneven and nodular. To palpate the penile urethra, the penis is grasped between the forefinger and thumb of the left hand just behind the glans, drawn up, and put upon the stretch. The urethra is then palpated between the forefinger and thumb of the right hand, each portion being picked up in turn from before backward. In marked cases of penile stricture, notable loss of elasticity of the entire canal is often perceptible when the penis is put upon the stretch.

The instrumental examination may be preceded by washing out the anterior urethra with normal salt solution. I prefer to omit the use of cocain in examining for stricture. It causes a contraction of the blood-vessels. The entire penis shrinks and feels harder. The elasticity of the urethra is diminished; as a result, a stricture will feel narrower than it really is. Moreover, the sensitiveness of the different parts of the urethra is not without diagnostic interest.

The patient should lie upon his back, his head supported, his naked body exposed from sternum to knees. The pelvis should be at right angles to the spine. The thighs should be slightly and equally abducted. The glans penis should be cleansed with soap and water, and then with a weak solution of bichlorid of mercury. If the meatus is markedly contracted the urethrometer may be introduced at once; if not, a sound as large as will pass without unduly stretching the meatus is lubricated, and introduced with due gentleness, according to the rules elsewhere given for catheterization. Either a blunt or conical sound may be used, according to the preference of the surgeon. When an obstruction is met, no force should be used; the instrument should be withdrawn and a smaller one substituted, until one is found which passes easily. When a sound is passed through a stricture, left for a moment *in situ*, and then withdrawn, a distinct sense of resistance is felt quite different from the entire want of such resistance exhibited by a normal canal. The stricture tissue grasps the sound quite firmly and opposes its withdrawal. The sensation is perhaps even more distinct when a flexible woven bougie is used. If no such grasping is felt when a good-sized instrument is used, there is no stricture.

A more accurate method of determining the size and situation of strictures is by the use of bulbous bougies. They can seldom be used satisfactorily beyond the bulbous portion. As large a one as will pass the meatus is introduced until an obstruction is met. It is withdrawn, and its distance from the meatus measured on the shaft with a ruler. A smaller bulb is then passed, until a size is reached which goes through. Upon attempting to withdraw the bulb, some resistance is felt. The shaft of the instrument is then grasped between the finger and thumb at the meatus, and the instrument slowly withdrawn. As it emerges from the grasp of the stricture a distinct jump may be felt. The instrument is again passed beyond the stricture, and withdrawn until resistance is felt. The shaft is again grasped at the meatus and the instrument removed from the urethra. The distance from the meatus to the shoulder of the bulb is measured. The difference between this and the former measurement indicates the length of the stricture, as well as its situation. These measurements are recorded. Thus the entire penile urethra to the end

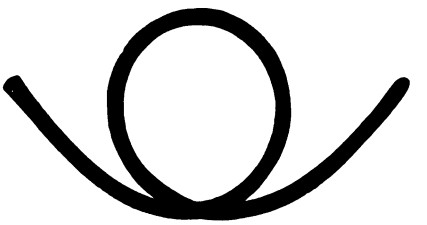


FIG. 230.—SOFT-RUBBER CATHETER SCALED IN INCHES, USEFUL IN DETERMINING THE "URETHRAL LENGTH, OR URINARY DISTANCE" UNDER MANY CONDITIONS.

of the bulbous portion is gone over, and all anterior strictures located and calibrated. These measurements are essential for the proper performance of internal urethrotomy with the Otis urethrotome. Strictures at and beyond the bulbous portion are frequently narrow. They are then safely explored with woven silk bougies, or with silk or whalebone filiforms. I am not in favor of the use of steel instruments attached to a soft guide for the diagnostic exploration of stricture. The temptation to use too large an instrument and too much force is very great. Laceration of the urethra and septic absorption are not improbable results.

It should be borne in mind that an obstruction deeper than six and one half inches—or, broadly, in the prostatic urethra—is not due to stricture, but to some other cause; most often to prostatic enlargement in the elderly, possibly to tumor, stone, or to a cicatricial prostate following abscess. Exploration of stricture should be followed by antiseptic irrigation of the urethra. If instruments have been introduced beyond the triangular ligament the bladder should also be irrigated.

In regard to the treatment of strictures, I believe that if stricture does not respond readily to gradual, intermittent dilatation, it should be cut. If properly cut, a large proportion of anterior strictures and a small proportion of deep strictures will be cured.

CHAPTER XXXIV

THE PENIS

CONGENITAL ANOMALIES

THE most frequent congenital anomalies of the urethra—namely, hypospadias and epispadias—have been elsewhere described. (See Urethra.) Other congenital deformities of the penis are rare. A very few cases of congenital absence of the penis have been reported. In some of these the testes and scrotum have been nearly normal. The development of the urethra has always been defective. In some instances it has opened into the rectum, a condition resembling the normal arrangement of the cloaca in birds. In others the urethra has opened in the perineum, the scrotum being cleft; in these cases the testes are often undeveloped, and may be undescended. The sex of these individuals may be hard to determine, since, if males, they are often of a feminine appearance.

Harris [1] found what he regarded as a certain means of differentiating the sex—namely, in the female the upper border of the pubic hair forms a nearly horizontal line across the hypogastrium, while in males it is prolonged upward in a curved line, or extends in a point to the umbilicus.

Though this is doubtless the rule, there are many exceptions. Statistics were collected upon this point by Lombroso and Ardu.[2] They found that the hair upon the pubes grew according to the male type, among women, in five per cent of normal women and female thieves and in fifteen per cent of prostitutes—234 cases examined.

A few cases of rudimentary penis have been recorded. In these the penis lay buried in the scrotum, or beneath the skin of the pubes.

Double Penis.—This is a rare deformity. In some of the reported cases the two organs lay closely side by side. The urethral opening was near the symphysis, and led into a single bladder. In two or more cases the two organs were entirely separated. Two bladders existed. In one case, that of Smith,[3] the patient could urinate from either bladder at will. A stone was removed from one of the bladders. In another case urine came from only one of the penes. The testicles lay in two separate sacs.

These anomalies possess but little surgical interest. In the cases where the

[1] Harris, *Lancet*, 1894, ii, 634. [2] "The Female Criminal," C. Lombroso, p. 326.
[3] "Trans. Med. and Chir., Faculty of Maryland," April, 1878.

penis lies buried beneath the skin of the scrotum or pubes, it should be liberated and covered with integument by a suitable plastic operation.

Phimosis.—Inability to retract the foreskin behind the glans is known as phimosis. The condition may be congenital or acquired. In the congenital form the orifice of the prepuce is so narrow that it does not permit the passage of the glans. The prepuce is often notably redundant. A slight narrowness of the preputial orifice is the rule in newborn infants. During the early years of life repeated retractions of the foreskin for purposes of cleanliness usually overcome the difficulty. If not retracted the accumulated smegma may give rise to marked irritation, leading to the formation of adhesions between glans and prepuce, or to the formation of preputial calculi, or to incrustations of the glans with calcareous material. Attacks of inflammation occur, leading to further cicatricial contraction of the preputial orifice.

Symptoms Produced by Phimosis.—If the preputial orifice is very small, dysuria results. The prepuce balloons up during urination and the urine is delivered through the narrow orifice in a fine stream. The prepuce may thus be dilated to a sac as large, in some cases, as a hen's egg. If an acute inflammation of the prepuce occurs, there may be complete retention. These children may be rendered seriously ill. They are predisposed to hernia from straining, and also, it is said, to hydrocele. As the result of the irritation they pull at the foreskin and readily learn to masturbate. Nocturnal enuresis is a common symptom. Priapism, prolapse of the rectum, frequent and painful urination, even cystitis—that is to say, symptoms closely simulating stone in the bladder—may be produced. In some cases there are marked nervous symptoms—irritability, sleeplessness, frequent crying, etc. If the condition remains unrelieved until adult life, the sexual functions may be interfered with. In advanced life, phimotic men are predisposed to cancer of the penis. When a phimotic individual acquires gonorrhea, chancroid, or chancre, the condition of the foreskin often invites serious complications.

Acquired Phimosis.—Inflammatory processes of the foreskin—balanitis, chancroid, chancre, and gonorrhea—may produce phimosis as the result of cicatricial contraction, or produce acute inflammatory phimosis, which may be transient or become permanent. In the acute cases an exact diagnosis may be impossible until the glans is uncovered by incision of the foreskin. Incision or circumcision are undesirable in chancroid and gonorrhea. In the former the wound is nearly sure to become chancroidal, and in the latter the local treatment of the urethra may be interfered with; still, in many instances it is better to expose the glans at all costs, since a destructive process may be going on beneath the tight foreskin which will cause serious loss of substance if unchecked.

Deformity of the Frenum.—The frenum may be so short that when the penis is erect the glans is pulled upon and bent downward. Erections may even be slightly painful; coitus may be notably so. The frenum may be torn during the act, and bleed quite freely. In these cases division of the frenum may be required.

INJURIES OF THE PENIS

Contusions of the Penis.—Superficial contusions of the penis are attended by marked swelling and ecchymosis, owing to the large size of the subcutaneous veins and the loose quality of the tissues. The flaccid penis may rarely be seriously contused by blunt violence, as in falls upon the pubes or run-over accidents. The condition rarely requires operative treatment, unless the urethra or the corpora cavernosa are torn.

Rupture of the Corpora Cavernosa, So-called Fracture of the Penis.—The injury occurs during erection, as from a violent movement during coitus or when the organ is seized and sharply bent by the hand. A similar injury may be caused by blows or falls upon the rigid member. The urethra may also be ruptured. The rupture of the corpus cavernosum is usually a horizontal tear in the tunica albuginea, and may be situated at any point from just behind the glans to just below the pubes. The cavernous tissue is rent more or less deeply. Immediate palpation before the penis swells may detect a sulcus in the corpus cavernosum.

Symptoms.—The symptoms are pain and tenderness, followed by rapid swelling and ecchymosis. The penis may swell to enormous size. If the corpus spongiosum and urethra are also torn, there will be bleeding from the meatus. There is often retention of urine. In some of the cases a large hematoma forms, and may require immediate incision and evacuation of the clots. The rent in the fibrous investment of the corpus cavernosum should be carefully sutured. It is probable that a better functional result would be thus obtained than by conservative treatment. If not operated upon, the blood will in some cases be absorbed; in other cases a large hematoma may remain for a long time, and may finally become infected and suppurate. If the urethra is also torn, the patient may have retention. In other cases he will urinate, with resulting urinary extravasation. Incision and suture of the torn urethra, with perineal drainage, are the safest procedure in these cases.

As the result of rupture of the corpus cavernosum some of the cavernous tissue is destroyed, and its place is taken by scar tissue. A nodular cicatrix remains. The function of the corpus cavernosum is impaired. The penis may be bent or angulated during erection, or the corpus in front of the scar may remain soft so that erection is unilateral in front of it. When both corpora cavernosa are torn, erection will be incomplete or absent on both sides. Penetration and satisfactory coitus may then be permanently impossible.

Constriction of the Penis.—For reasons best known to themselves, children, and sometimes adults, surround the flaccid penis with ligatures, or draw over the glans onto the body of the penis hollow articles of various kinds. Hairs, threads, strings, etc., are used for ligatures. Gold or other metal rings, metal washers and nuts, tin cans, bottles, the head of a hammer or ax, and many other things have been drawn onto the penis by men—sometimes for purposes of masturbation, sometimes for no assignable reason. The pressure of the ligature

or ring causes interference with circulation, and rapid swelling of the organ distal to the constriction. The ligature or ring, if narrow, soon disappears in a furrow of the swollen integument. The penis becomes congested, the glans blue and greatly enlarged. Gangrene of the skin soon occurs at the point of constriction; thus the interference with circulation in the distal portion of the organ may be wholly or partly relieved. The skin may even heal over the foreign body, and it may thus remain for a long time without giving much trouble. In most cases, pressure upon the urethra causes retention of urine, and this symptom, together with pain and fright, drive these patients to seek medical advice.

In some cases pressure necrosis of the urethra has occurred with the formation of a penile urinary fistula. In other cases, more or less extensive gangrene of the penis and urethra has resulted.

The diagnosis is simple except in those cases where a fine ligature lies buried in the tissues and the true history is not obtainable. In these the surgeon may be puzzled for the moment.

Incised, Contused, and Gunshot Wounds of the Penis.—Accidental incised wounds of the penis are rare. Many incised wounds of the penis are self-inflicted. Lunatics and religious fanatics sometimes seek to mutilate themselves by cutting off their own genitals, the latter in the hope of ridding themselves of the tortures of ungratified sexual desire. Savage peoples sometimes mutilate captives in this manner. Some of the warlike tribes of American Indians practiced such mutilations upon dead and wounded enemies, and upon captives. The same practices are said to exist among certain savage African tribes. In the Orient, the most valuable eunuchs are those from whom penis, scrotum, and testes have been cut away.

Wounds of the penis made with criminal intent are not very rare. They are usually inflicted by women from revengeful jealousy. The most favorable opportunity is offered during coitus, and a razor is the favorite weapon. The cuts are transverse or oblique. The penis may be wholly or partly severed. The partial amputations usually involve the urethra. Bleeding is severe, but rarely fatal. Even though the corpora cavernosa are nearly severed, gangrene does not necessarily follow. Careful suturing should be done. If the urethra is cut, it should be sutured. Perineal drainage renders the prognosis better in these cases.

Stab wounds of the penis are less common than incised wounds. They are usually accidental, as when the patient falls against a pocketknife, a pair of scissors, the sharpened end of a lead pencil, the tip of an oil can, etc. The accident may occur from a fall when the wounding instrument is in the trousers' pocket.

The diagnosis offers no difficulties. Injury of the urethra should be excluded.

Contused and lacerated wounds of the penis are more common than incised wounds. They occur from a variety of causes. As stated under Urethra, the

erect penis may be torn away from the body by the hand. A certain number of cases are furnished by machinery accidents, as when the trousers are caught in moving belting or in geared wheels and the penis and scrotum drawn into the grip of the machinery. These injuries are often very severe. The penis and testes may be completely crushed or torn away from the body. In others the prepuce is torn away from the base of the glans. In these the penis retracts beneath the skin of the pubes or scrotum, producing the condition known as "dislocation of the penis." The diagnosis is simple. A bloody hole is found in the skin where the penis ought to be. The organ itself is found buried beneath the integument. Bleeding is often profuse, and infiltration of urine may follow unless the penis is pulled out and sutured to the foreskin. In some cases the penis forms adhesions in its new position, and a careful dissection and a plastic operation are required for its replacement and covering.

The bites of animals—as, for example, dogs, wolves, and sharks—may be mentioned as capable of causing serious laceration of the penis and scrotum. I knew an elderly sailor man who told me he had examined an unfortunate wretch whose penis and scrotum had been bitten cleanly away by a shark. He had inspected the wounded individual a few minutes after the accident happened.

Gunshot wounds of the penis are not very rare in warfare. The injury is commonly associated with wounds of the pelvis, thighs, scrotum, bladder, or rectum. The urethra is usually opened. Perineal drainage is called for in some of these cases. The diagnosis is to be made from the data given under Rupture of the Urethra.

DISEASES OF THE PENIS

The diagnosis of gonorrhea, syphilitic chancre, chancroid, and herpes preputialis is discussed in the sections devoted to these topics.

Balanitis—Balanoposthitis.—Inflammation of the glans (balanitis) and of the foreskin (posthitis) regularly coexist. A long, tight prepuce predisposes to their occurrence. Want of cleanliness and diabetes are also predisposing causes. As exciting causes may be mentioned contact of the glans and foreskin with irritating discharges, whether gonorrheal, syphilitic, or chancroidal. Contact with decomposed vaginal discharges, whether catarrhal or menstrual, is also capable of exciting balanitis. Among the circumcised, typical balanoposthitis does not occur. Mechanical injury, as in coitus, to which pyogenic infection is added, may produce balanitis in a man with a long, tender prepuce. Minute tears and abrasions of the inner layer of the prepuce afford favorable avenues for infection. Among the diabetic, the fungi growing in the saccharine urine retained beneath the prepuce act as an exciting cause of balanitis. Among children, concentrated acid urine may irritate the foreskin and glans so that their secretion becomes a favorable source for pyogenic germs. The same irritation renders the epithelial covering vulnerable.

Symptoms of Balanitis.—At the beginning of an acute attack there are itching and burning pain felt in the glans and prepuce, together with burning pain as the urine passes over the inflamed foreskin. The prepuce and glans become reddened, swollen, and finally excoriated, at first in spots, later diffusely. True ulceration very rarely occurs in simple cases, except in diabetics. When complicated by chancroid or chancre, the conditions are of course quite different. The subjective symptoms are itching and burning felt in the penis, and scalding pain during urination. From beneath the foreskin a thin, evil-smelling discharge escapes, consisting of serum, pus, bacteria, and desquamated epithelial cells. Inflammatory phimosis is often present. The entire prepuce may become edematous and red. Lymphangitis is common in children, together with enlargement and tenderness of the inguinal lymph nodes. These rarely suppurate. In adult and elderly men the condition may become chronic. The skin of the prepuce and glans may become granular, moist, and raw over certain areas, white and thickened over others. Acuminate warts are a frequent result of the irritation. Firm adhesions may form between the glans and prepuce. The condition is only curable by circumcision. The operation is urgently demanded in these cases, since a large proportion of the cases of cancer of the penis have been preceded by this form of chronic balanitis.

Inoculation tuberculosis of the prepuce has been observed after the Jewish rite of circumcision, the infection having been conveyed by the mouth of the tuberculous rabbi.

Diphtheria of the prepuce may complicate faucial diphtheria, or may rarely occur upon the wound of circumcision.

Noma of the penis and scrotum is discussed under Gangrene.

Diagnosis.—When the foreskin can be retracted the diagnosis of simple balanitis offers no difficulties. If phimosis exists and the symptoms are severe in spite of cleanliness, mild antiseptic washes, etc., the glans should be exposed by incision. Chancre or chancroid, if present, may then be readily recognized from their specific characters.

Paraphimosis.—When the foreskin is retracted behind the glans and cannot be replaced, the condition is known as paraphimosis. A tight preputial orifice is a predisposing factor. Any inflammatory or other infection attended by swelling of the foreskin may be the exciting cause of an attack. Such are balanitis, gonorrhea, herpes, chancre, chancroid, trauma, whether during coitus or other, edema from cardiac, renal, or hepatic disease. It may not be generally known that the application of orthoform to the prepuce will often produce very marked edema of the entire cutaneous covering of the penis.

Symptoms.—The narrow ring of the foreskin, having been retracted behind the corona, cannot be replaced. The circulation of the glans and prepuce is interfered with by this constricting band. Swelling follows, and skilled manipulation or division of the constricting band are necessary to obtain relief. The glans penis swells, often to twice its normal size, and is blue in color. Behind the corona the mucous layer of the foreskin presents as a prominent red or

blue, shining, edematous collar. Another and posterior ridge is formed by the swollen integument of the penis. Between them, hidden in a deep sulcus, lies the constricting border of the foreskin. It is usually invisible until the skin of the penis has been strongly retracted toward the pubes. If the condition remains unrelieved the glans continues to swell and becomes bluish-black, cold, and insensitive. Gangrene of the glans with loss of substance is, however, extremely rare. Usually the constricting band of skin undergoes necrosis, with partial or complete relief of the constriction.

Cases of Paraphimosis without Constriction.—In a certain proportion of cases the prepuce may be greatly swollen as the result of inflammation or edema due to any of the causes mentioned, so that it cannot be replaced over the glans, and yet no actual constriction will be present. The circulation of the glans is not interfered with. The glans is neither blue nor greatly swollen.

In the cases showing interference with circulation the foreskin must be replaced immediately, either by manipulation or operation. In the group showing no such interference, cleanliness and local sedative treatment suffice. Immediate reduction is not imperative.

Erysipelas of the Penis.—Primary erysipelas of the penis is rare. Usually the infection starts in neighboring structures and spreads to the penis. The disease is sometimes of the phlegmonous type, with marked destruction of tissue, and sometimes fatal results. I have seen but one case of erysipelas primary in the penis. The infection followed a scald of the penis, and spread rapidly to the scrotum, abdominal wall, and thighs. The patient at once became delirious, and died with a very high temperature on the fourth day of the disease.

Acute Pyogenic Infection of the Penis—Cellulitis, Penitis, and Cavernitis.—Acute pyogenic infection of the skin and subcutaneous tissues of the skin may follow wounds of the penis, urinary infiltration, gonorrhea, chancroid, as well as other and less frequent causes. The general symptoms are those of sepsis. Locally there is marked swelling, ending often in extensive tissue necrosis or gangrene.

Lymphangitis of the penis may accompany any local infection. A hard, tender cord of inflamed lymphatics may be felt on the dorsum of the organ leading toward the groin.

Cavernitis.—Suppurative inflammation of the corpora cavernosa may follow the same causes as those just mentioned for cellulitis. A localized, palpable infiltration forms in the corpus cavernosum, and eventuates after some days in an abscess. In other cases the infection becomes diffuse, and is accompanied by severe septic symptoms. Priapism is said to be a marked symptom in the severe cases. It is due partly to inflammatory infiltration, partly to interference with the escape of blood from the cavernous spaces. If the patient survives long enough, sloughing or gangrene and extensive loss of substance occurs. Notable deformity of the organ remains if the patient finally recovers. Pyemia is a frequent and fatal complication.

Chronic Cavernitis.—A condition which is due, probably, to one of several causes, and characterized by the development in the corpora cavernosa of firm fibrous or calcareous nodules or plaques. These nodules and plaques are readily palpable. They sometimes cause pain during erection, and occasionally angular deformity of the penis. Infection of the corpora from gonorrhea, gout, and sclerotic changes in the blood-vessels of the cavernous tissue have been assigned as causes for these plaques. In the cases I have seen the nodules occurred near the pubes, and upon the dorsal aspect of the penis. In one case an X-ray picture showed a shadow of the nodules, evidence that they contained earthy or other mineral salts. The nodules may be multiple, and may then cause marked deformity of the erect penis. They may, it is said, press upon the urethra and interfere with ejaculation.

Elephantiasis of the Penis and Chronic Lymphatic Edema of the Penis.—The scrotum is one of the commonest sites of lymphatic obstruction produced by one or other of that group of nematode worms whose embryos cause the disease known as "filariasis." The penis, on the other hand, is only occasionally, indeed, rather rarely, affected. The commonest parasite is Filaria Bancrofti. The disease produced is Filaria sanguinis hominis nocturna. The embryos are transmitted to the human host by the bites of one of several varieties of mosquito. The female mosquito bites an individual, whose blood at night is filled with embryo worms. She draws into her stomach a number of embryos along with the blood. These burrow into the tissues of their host, find their way into her head, and there, after several weeks, mature. The mosquito again bites a human being, and the embryos, male and female, enter the tissues of their new host. They follow the lymphatic vessels to the periphery, mature, and there breed. The new embryos enter the blood current and reëstablish the disease filariasis. It is believed that the female may abort and discharge her eggs into the lymph channels. The unhatched eggs are larger in diameter than the perfect embryos, and may, it is believed, cause lymphatic obstruction. The mature worms also set up such an amount of inflammation that the lymph channels they occupy are blocked, thereby causing obstruction to the lymph current.

Diagnosis of Filariasis.—The diagnosis is easy when the embryos are in the blood. In the nocturnal form the blood of the patient swarms with parasites at night. They are about the diameter of a blood-corpuscle and 180 μ in length. They show an active, writhing movement, but do not advance independently of the blood current from place to place. The embryos disappear from the blood toward morning, and are not found during the day. The adult worm has a diameter about equal to that of a human hair, and is from three to six inches in length. They are very delicate, easily broken, and are hard to find in the tissues.

By these parasites, whose characters are here briefly sketched, are caused among other lesions elephantiasis. Some of the other conditions to which they may give rise are thus enumerated by Manson: abscess, lymphangitis, vari-

cosity of the inguinal and of the axillary lymph nodes, lymph scrotum, cutaneous and deep lymph varix, orchitis, chyluria, chylous dropsy of the tunica vaginalis testis, chylous ascites, and diarrhea, elephantiasis of the scrotum, penis, leg, arm, etc.

Tropical, mosquito-infested lands are the home of the disease, but isolated cases are seen in the temperate zones. Lymphatic obstruction is, however, by no means always present, nor can the parasite always be identified in the blood when lymphatic obstruction exists. The diagnosis must then rest upon finding the adult worm in the tissues or the embryos in the discharge from a lymph fistula of the part affected, upon the presence of chyluria, upon the history, together with the absence, of other causes of lymphatic obstruction. As a rule, operative removal of the affected tissues is only palliative. Either the adult worm is inaccessible or there are many worms. *Elephantiasis arabum*, the condition caused by the parasite to distinguish it from *Elephantiasis græcorum*—i. e., *leprosy*—is characterized by an enormous hypertrophy of the skin and connective tissues of the affected parts. (See Scrotum.) The penis is, as stated, rather rarely affected; when involved, the organ may be increased in size to huge proportions. Cases are reported where the penis has reached the length of two feet. The skin becomes hard, brawny, and warty. The surface is the seat of excoriations, and between the folds of hardened epidermis, eczema, blebs, and ulcerations may form. From the last a milky, chylous fluid is discharged, sometimes containing filarial embryos.

Numerous other causes of lymph edema of the penis exist. Many cases are due to obstruction of the lymph channels in the groins, as from extirpation of the lymph nodes of both groins, the pressure of a double truss. The enlargement of the penis and scrotum may be marked and the resulting discomfort great. The diagnosis rests upon finding the cause of lymph obstruction other than filariasis. Chronic inflammatory processes of the penis itself, as from balanitis, syphilis, and chancroid, may cause marked enlargement of the organ from edema and the formation of new connective tissue.

TUMORS OF THE PENIS

Benign Tumors

Cystic Tumors of the Penis.—Cystic tumors of the penis of various kinds have been observed. They are seldom of much surgical importance. Traumatic epithelial cysts were described by Trzebicky, following circumcision. I removed some years ago a nodule from the penis of a man who had been circumcised several years before. The mass was the size of a large pea, hard and insensitive, movable beneath the skin. It consisted of fibrous tissue, containing in its center a nonabsorbed catgut ligature.

Cystadenoma, in the form of a small, tense cyst of the prepuce containing jellylike fluid, was described by Fischer.

FIG. 231.—LIPOMA OF THE PENIS. A very rare tumor. (Case of Dr. L. W. Hotchkiss, Bellevue Hospital.)

Atheromatous cysts of small size are not infrequent. They are often multiple, and are observed upon the glans as well as upon the general integument of the organ.

Dermoids of small size have been reported, usually situated in the median raphé of the penis.

Lipoma.—Lipoma of the penis is rare. The illustration (Fig. 231) was taken from the photograph of a case seen in Bellevue Hospital.

Papillomata of the Penis.—Acuminate warts of the penis occur with great frequency. They are pink, sensitive, vascular, cauliflowerlike growths, usually pedunculated and generally multiple. They occur upon the mucous layer of the prepuce at its junction with the glans, upon the glans itself, sometimes at or within the meatus, less commonly upon the body of the penis. Though known as venereal warts, they have no necessary relation to venereal disease. They occur most often beneath a long prepuce. Lack of cleanliness and the irritation produced by retained and decomposed smegma are predisposing causes. They are often associated with balanitis and a foul discharge. In some cases they grow very large, indeed. Fig. 87 (vol. i, page 253) shows a very large mass of such papillomata in a case I operated upon some years ago. The condition had been mistaken for cancer by another surgeon. The growths were ulcerated in places, and gave out a disgusting, fetid dis-

FIG. 232.—LIPOMA OF THE PENIS. A very rare tumor. (Case of Dr. L. W. Hotchkiss, Bellevue Hospital.)

charge. Cancer may grow upon such papillomata as a basis; therefore, when doubt exists, a portion of the base of the tumor should be removed for microscopic examination.

Horns.—The occurrence of horns upon the penis is exceedingly rare. A few cases only are to be found in literature. The horns have been situated upon the glans and corona, and have consisted of horny plaques or considerable projections. The growths have usually been observed in old men. Neglect of cleanliness, a long foreskin, and mechanical irritation have been causative factors. Here, as elsewhere, horns may become the starting point of cancer.

FIG. 233.—SOFT PAPILLOMATA OF PENIS, ACUMINATE WARTS, INFLAMMATORY PARAPHIMOSIS. (New York Hospital Collection.)

MALIGNANT TUMORS OF THE PENIS

Sarcoma.—Sarcoma of the penis may occur as a primary or metastatic growth.

The several forms of sarcoma, including melanotic sarcoma, have been observed in the penis both as primary and secondary tumors. Combinations of sarcoma with fibroma and angioma are also reported. As elsewhere in the body, sarcoma of the penis follows injury in a moderate proportion of cases. Sarcoma originates in the corpora cavernosa, less frequently in the corpus spongiosum. The tumors occur as firm or elastic nodules in the body of the organ or glans, followed later by a diffuse infiltration. Ulceration here, as elsewhere, occurs much later than is the case with carcinoma. Secondary tumors form very early in the groin, the testicles, and prostate. Deformity of the penis and angulation during erection may be early symptoms. When both corpora cavernosa are infiltrated, true erections do not occur, though a sort of pseudo-priapism may exist when the corpora are extensively infiltrated with sarcomatous tissue. The urethra may be compressed, causing dysuria.

Diagnosis.—Sarcomata are distinguished from carcinomata by their deep-seated origin in the corpora cavernosa, by their nodular form, and by the absence or late occurrence of ulceration. The history of sarcoma of the penis does not differ materially from that of sarcomata in other situations. If the penis is amputated early and the inguinal glands removed, the prognosis is not absolutely bad except in the case of melanotic sarcoma. It is, of course, highly important to discover whether the tumor is primary in the penis or not.

Cancer of the Penis.—*Epithelioma* of the penis is the most frequent tumor of that organ, papilloma excepted. About three per cent of all cancers in males occur on the penis. It is a disease of advanced life, rare before the fiftieth year, though occasionally observed during the fourth decade. A long foreskin, want of cleanliness, and the chronic irritation resulting from retained and decomposed smegma are important causative factors. The chronic balanitis accompanying the above conditions is very commonly present. There is a history of previous injury in a moderate number of cases. Epithelioma may begin in the base of a moist papilloma.

A form of chronic balanitis characterized by the development of raw, moist surfaces on the glans penis, alternating with or bounded by areas of smooth, white, glistening, thickened epithelium, is a condition which seriously threatens cancer.

Küttner, who made a careful and exhaustive study of cancer of the penis, classified the epitheliomata of this region into three groups: (1) Papillary, cauliflowerlike growths; (2) cancerous ulcers; (3) nonpapillary, cancerous tumors.

1. *Papillary, Cauliflower Growths.*—The tumor begins on the inner layer of the prepuce, or on the glans, as a warty nodule, which soon ulcerates. The ulcer has a hard base, hard and everted edges, and gives forth a foul, thin discharge. The usually phimotic foreskin is soon perforated in front. As the ulceration proceeds the partly destroyed glans is exposed. Less commonly the tumor starts on the cutaneous surface of the foreskin. In other cases a warty growth forms on the glans, spreads rapidly, forms new papillary outgrowths of various sizes and shapes. Thus a prominent tumor is produced, of irregular outline and surface, bearing a strong resemblance, both superficially and on section, to a cauliflower. If the disease commences in the foreskin the hard infiltration will prevent its retraction; if in the glans, a paraphimotic condition results.

Those portions of the tumor which are kept moist by urine and by contact with the prepuce are soft; the parts exposed to the air, firmer. Along with the formation of tumor tissue, ulceration proceeds. The older parts of the tumor slough, with putrid decomposition. The urethra is often perforated. Though the corpora cavernosa commonly resist invasion for a long time, they are sooner or later infiltrated, and the formation of tumor masses and of tissue necrosis advances toward the root of the penis until, in old cases, the organ ceases to be recognizable. The pubic region is occupied by an irregular,

cauliflowerlike mass, composed partly of growing cancer, partly of sloughing tumor tissue. From a cleft or pit in the surface of the mass the urine is discharged.

2. *Cancerous Ulcers.*—This form of cancer of the penis begins usually upon the glans or corona, as an ulcer with a firm base, and borders showing papillary outgrowths. It differs from the first form chiefly in that the ulcerative process is more rapidly progressive. Cancerous involvement of the inguinal lymph nodes may occur at an early period, while the original tumor is quite small.

FIG. 234.—EPITHELIOMA OF THE PENIS, ULCERATING TYPE. (Collection of Dr. E. Eliot.)

3. *Nonpapillary Cancer of the Penis.*—Nonpapillary cancer of the penis is a rare variety. It usually begins in the glans, and is characterized by the formation of a solid tumor of considerable size which does not show the same tendency toward early ulcerations as the other forms. Upon section the tumor does not show a papillary structure, but rather resembles, in gross appearance, carcinoma-simplex, such as is observed in cancer of the breast.

Progress of the Disease.—Cancer of the penis spreads by (1) continuity of structure; (2) by the formation of new cancerous nodules in the corpora cavernosa; (3) by the invasion of the inguinal lymph nodes. The duration of the growths before the lymph nodes are invaded varies a good deal in different cases; in some it is early, in some it is late. The inguinal lymph nodes act as a barrier to general dissemination by the lymph current beyond which the disease rarely spreads. Locally, tumor masses and progressive ulceration of the inguinal regions are features of advanced cases. In a few cases the lumbar lymph nodes are first involved. Metastases in distant organs are extremely rare, and general infection through the blood current does not appear to occur. By continuity of structure the tumor may invade the suprapubic region, the scrotum, testes, groins, perineum, bladder, and prostate. Death is due to chronic sepsis and to exhaustion, rarely hastened by repeated bleeding from the ulcerated surfaces.

The microscopic appearances of epithelioma of the penis resemble those of skin cancers in other regions.

Symptoms.—The development of cancer of the penis has been sufficiently indicated in the preceding paragraphs. During the early stages of the disease pain is not a prominent symptom. Later on sharp pain is felt in the penis, radiating into the thighs, scrotum, perineum, and rectum. When ulceration is advanced the raw surfaces are tender and painful. In some cases the urethra may be partly occluded. There will then be dysuria, in addition to the pain felt as the urine passes over the ulcerated surfaces. From the ulcers there escapes a purulent, thin, evil-smelling, often putrid, discharge. The raw surfaces bleed readily, but the hemorrhage is rarely severe.

Diagnosis.—The disease may be confounded with acuminate warts. The latter have a soft base. If the diagnosis is doubtful, a portion of the base of the tumor should be cut away for microscopic examination. In cases of phimosis in elderly men, the continued presence of a fetid discharge from beneath the foreskin is in itself enough to arouse a suspicion of cancer. The glans should be exposed at once by incision in such cases. It is to be borne in mind that there is a history of phimosis and of chronic and relapsing balanitis in a very large proportion of all cases of cancer of the penis.

From *chancroid*, cancer of the penis is to be distinguished by the acute onset of the former, the absence of induration, the acute pain and tenderness, the multiplicity of the auto-inoculable and distinct ulcerated surfaces, and, finally, in chronic cases of chancroid, by microscopic examination of a portion of the base of the ulcerated area.

Ulcerated syphilitic chancres sometimes simulate cancer of the penis quite closely. A history of exposure, response to active mercurialization, and microscopic examination will render the diagnosis clear in doubtful cases. At present the identification of the Spirochæta pallida in the scrapings from syphilitic ulceration is regarded as pathognomonic. The diagnosis should, however, be intrusted to none but a highly skilled pathologist. *Gummata* of the glans penis are usually deep-seated, distinctly circumscribed, nodules which, after attaining a definite size, show but little tendency toward further increase. When recently broken down, the characteristic, insensitive, sloughy base of the crater-formed ulcer is often distinctive. In cases of doubt, the microscope and the use of large doses of iodid of potassium will establish the diagnosis. In advanced cases of cancer of the penis the diagnosis can usually be made at a glance.

Prognosis.—The outlook in cases of cancer of the penis is bad when the lymph nodes of the groin are already involved. Both groins should be carefully examined, since the cancer may be on one side of the penis and the bubo in the opposite groin. In some cases the lymph nodes are involved very early, and may be detected on palpation as spherical, hard, shotlike bodies in the inguinal region. It is to be borne in mind that the lymph nodes of the groin may be enlarged and tender through absorption of septic material from the ulcerated surfaces commonly present on the penis. Hence, in forming a prognosis in the given case, the lymph nodes should always be subjected to micro-

scopic examination. In some cases cancerous infection of the lymph nodes is long delayed. While the glands remain free, extirpation of the penis and extirpation of the lymphatic structures of both groins offers a fair prospect of cure. Thus, Küttner reported a mortality of 40.5 per cent in 58 cases, reported from three to twenty-nine years after operation.

CHAPTER XXXV

THE SEMINAL VESICLES AND THE SEMEN

Anatomical Remarks (partly adapted from Merkel).—*The Seminal Vesicles.*—The seminal vesicles are placed one on either side of the median line, between the base of the bladder, above and in front, and the pelvic portion of the rectum behind. They extend from the base of the prostate upward, backward, and outward for about two inches. Below they are about 2 cm. apart; above, at their extremities, about 6 to 7 cm. They are but loosely attached to the bladder, though adherent to the rectum, and are somewhat movable from side to side. The upper thirds of the vesicles are covered by peritoneum, and hence, anatomically, an abscess of a vesicle might burst into or infect the peritoneum by continuity of structure, or into the bladder or the rectum, as the case might be. The lower portions of the vesicles are palpable through the rectum, though deep pressure against the perineum is necessary to reach above the prostate. They are more readily felt when the bladder is moderately distended. Bimanual palpation is an aid in slender subjects. The vesicles are more readily felt when distended with secretion or dilated from obstruction of their ducts, and still more readily when inflamed and indurated from pyogenic infection or tuberculosis.

The vesicle consists of a convoluted, blind tube, about four inches in length, having many lateral blind pouches and sacculi, inclosed in a thin, fibrous capsule, but loosely attached, and containing some muscular fibers. In health their lower thirds feel like two irregularly cylindrical bodies, of elastic, soft consistence, extending upward from the prostate, separated by the width of a finger.

One or both vesicles may be absent. The testes are commonly wanting in the latter case. The vesicles vary much in size, not only in different persons but in the same individual on the two sides. One, usually the right, may be much larger than the other.

The Secretion of the Seminal Vesicles.—The secretion of the seminal vesicles consists of a viscid, opalescent fluid. It is usually seen intimately mixed with the secretion of the testes—i. e., the spermatozoa. The vesicles probably act to a considerable extent as storehouses for the semen. This is shown by the fact that in a normal individual who has been continent for some time the vesicles can be more distinctly felt and their distention recognized by touch than if palpated soon after sexual intercourse.

Injuries of the Seminal Vesicles.—Owing to their protected position the vesicles are seldom injured by direct accidental violence from without. Injuries of the vesicle from fractures of the pelvis (ischium) has been reported. They may be wounded during operations upon the deep structures of the perineum, prostatectomy, Bottini's operation, prostatotomy, lateral lithotomy, extirpation of the rectum for carcinoma. Wounds of the vesicles or of the ejaculatory ducts may result in obliteration of the duct, and consequently, if bilateral, in sterility. After lateral lithotomy, a spermatic fistula sometimes results, but usually heals spontaneously.

Method of Obtaining the Contents of the Seminal Vesicles for Purposes of Examination.—The patient passes his urine. The urethra and bladder are then washed clean with salt solution, and eight ounces are allowed to remain. The contents of the prostate are then carefully expressed by the finger in the rectum. A smear may now be taken from the meatus for microscopic examination. The patient now partly empties his bladder, to wash out the urethra. The finger is then introduced into the rectum as far as possible, and the seminal vesicle is then repeatedly and firmly stroked from above downward on one or both sides. Some care and practice are necessary to express the contents of the vesicle. The patient should bend his body over the back of a chair while the surgeon stands behind him. Since very firm pressure is needed against the perineum in order to reach the vesicles, the patient's body should be solidly supported. The surgeon's right forefinger is introduced into the rectum; he stands with his own elbow pressed against his own side, so that the weight of his body may be transmitted through the forearm and the examining hand; the same attitude, in fact, assumed in making a deep examination of the pelvic organs of women. The forearm, wrist, hand, and forefinger should be held in a straight line, the third, fourth, and fifth fingers sharply flexed into the palm. Palpation is made by flexion of the terminal joint of the index finger. Thus the weight of the surgeon's body helps to invaginate the soft tissues of the perineum, and by attention to these details one is enabled to reach a good deal higher. Some of the contents of the vesicle will usually appear at the meatus, and may be examined at once. If not, the patient empties his bladder, the liquid discharged is centrifuged, and the product examined under the microscope. As stated, spermatozoa will probably be found in moderate numbers. If, in addition, the fluid contains numerous pus cells, the seminal vesicle is inflamed. Search for gonococci should be made in a stained specimen, and if such be found, the fact will explain the obstinate persistence of chronic and relapsing gonorrhea in a certain proportion of cases.

Some *diagnostic data* of interest are obtainable from the pathological changes in semen. Semen may be collected as ejaculated into a rubber condom during sexual intercourse, or, in default of this, some conclusions may be drawn, as already stated, by stripping the seminal vesicles or by examination of seminal stains as they occur in the dried state upon the linen after nocturnal

emissions. If it is desired to examine the semen in a fresh state, a string should be tied carefully about the base of the condom. This may be brought for examination immersed in a preserve jar containing warm water. The *quantity* of semen evacuated at one time varies greatly among different individuals, and, in the same individual, according to the time elapsed since a previous ejaculation. On the average, the amount varies between 10 and 15 c.c. in a vigorous, healthy man. If coitus is repeated several times during the same day, the quantity of semen and the number of spermatozoa diminish, so that in some cases the last ejaculation contains but few. The freshly ejaculated semen of a healthy man resembles cooked starch in appearance, is of alkaline reaction, and has a peculiar and characteristic odor. It is a thick, viscid fluid. After standing for some hours it separates into two layers—a dense, white layer at the bottom and a clearer, supernatant fluid. As ejaculated, it contains several secretions—namely, that of the testes, the seminal vesicles, the prostate, the mucous glands of the urethra, and the glands of Cowper.

Microscopic Examination (details adapted from R. Ultzmann).—Under the microscope we find, in addition to spermatozoa, the so-called semen corpuscles, and epithelial cells from the lower genito-urinary tract. Before puberty no spermatozoa are produced. In extreme old age spermatozoa may be absent, and yet it is by no means rare to find very old men whose semen contains abundant and active spermatozoa. A drop of fresh semen placed under the microscope should show at least a hundred living spermatozoa in every field, when viewed with a Reichert objective No. 7, eyepiece No. 3. The microscopic field shows a picture of vigorous life and movement. The spermatozoa scurry about in all directions. They move rapidly through the narrowest channels between adjacent cells, and never collide with anything. Each spermatozoön consists of a head, a tail, and a middle piece. The head is pear-shaped and flattened; the tail gradually tapers from the slightly thickened middle portion to a very fine filament, ten times longer than the head. Healthy, normal semen, protected from light and cold, shows active motions of the spermatozoa after forty-eight hours. When the spermatozoa are dead they remain, if healthy, for the most part straight. If the tails are found sharply angulated or curled up, they were probably ejaculated in this condition, or killed by an abnormal vaginal secretion or other noxious substance. Such forms are very common in the semen of those men who, on account of local disease, furnish only dead spermatozoa. It is to be borne in mind that the addition of water quickly kills spermatozoa, and may cause their tails to curl up. The same is true of abnormally acid vaginal secretion. Certain substances in solution are capable of rendering the motion of the spermatozoa more active, and even of reviving them when their movements have ceased. All alkaline animal secretions belong to this class, while all acid secretions inhibit their motility. The salts of the alkalies, solutions of sugar, albumin, and urea increase their motions. Acids and metallic salts stop their movements.

The Pathological Changes in Semen.—The pathological changes in semen are various. They are as follows:

Aspermatism.—In this condition the individual ejaculates no semen under any circumstances, neither during coitus nor at any other time. The condition may be permanent or temporary. It may be absolute or relative. *Permanent aspermatism* is rare as a congenital condition, though not infrequent as an acquired one. In the congenital and permanent form the individuals never during their entire lives have an ejaculation of semen. They may be capable of erection and able to perform coitus, but the act, however prolonged, is not followed by an orgasm nor by the ejaculation of semen. The genital organs of these persons may appear to be perfectly normal. A moderate number of such cases have been reported in literature. The acquired form follows obliteration of the ejaculatory ducts. It is seen after abscess of the prostate, after many cases of prostatectomy, and after the removal of the seminal vesicles. Obliteration of one ejaculatory duct is more common; it may follow operations upon the perineum. The quantity of semen is diminished, but it is not absent. Tuberculosis of the prostate, the seminal vesicles, and of the epididymes may be followed by absence of semen.

Temporary aspermatism is not at all uncommon. It is sometimes observed in cases where the sexual apparatus appears to be quite normal. Some of these individuals are highly neurotic men who are candidates for matrimony. They are sometimes men of high intellectual development, who have led very continent lives and who approach the married state with much trepidation. They are often neurasthenic from overwork, anxiety, or other cause. Such men may for a time after marriage find themselves incapable of having an ejaculation. In these cases the condition often disappears spontaneously. In other cases temporary aspermatism occurs in individuals who have committed sexual excesses, or who have been habitual masturbators, or who have had a severe gonorrhea with complicating posterior urethritis, prostatitis, and epididymitis. In these cases the disease has caused a mechanical or other interference with the nervous mechanism of ejaculation. In this group the condition may last for weeks or months, and may then be recovered from quite suddenly. Some of these patients are also impotent, all attempts at coitus are failures, and yet they may have nocturnal emissions under the influence of dreams. A rare form of aspermatism was described by Ultzmann: These patients have sexual desire with erections, but they are unable to procure an emission during coitus. They proceed to have intercourse with a rigid member, but though coitus be prolonged to the point of physical exhaustion, they do not have an emission. Immediately, upon falling asleep, emission occurs, under the influence of a dream. I have already mentioned that form of partial or complete absence of ejaculation which occurs as the result of tight stricture of the urethra. In these cases the urethra is too narrow at the point of stricture to permit the escape of semen during the orgasm. A little may appear at the meatus, but most of it goes back into the bladder, to be expelled during urination. The

retention of semen in the urethra behind the stricture explains the sharp pain felt during the orgasm by these patients. A part of the semen may be retained between the verumontanum and the stricture, and escape slowly through the meatus when the erection subsides. Most of these cases are curable by division of the stricture.

Polyspermatism.—An increased quantity of semen is much more rare than its diminution, though probably, the condition being in no wise pathological, the individuals affected are not apt to seek medical advice, and hence may escape observation. In these cases the quantity of semen ejaculated may be two or three times the usual amount. The quality of the semen remains normal. The excessive volume is made up, not of an increased number of spermatozoa but of the secretion of the seminal vesicles. Ultzmann mentions a case in which each ejaculation amounted to about 35 c.c.

Oligospermatism.—A diminished quantity of semen is observed, as stated, after frequently repeated coitus and in old age. Neither of these conditions are pathological so long as the semen contains living, healthy spermatozoa; though the amount be small, such individuals are perfectly capable of impregnating the female. A diminished quantity of semen is often observed after gonorrheal prostatitis, and after epididymitis and seminal vesiculitis. In these cases the decreased quantity is due to the absence of one or other of the normal ingredients of semen. Thus, epididymitis, if bilateral, is often followed by obliteration of the vasa deferentia. The semen then contains no spermatozoa, and consists merely of the secretion of the vesicles, prostate and urethra. In some cases the secretion of the vesicles is diminished in amount, thus decreasing the quantity of semen.

Variations in the Color of the Semen.—The variations in the color of semen were carefully studied by Ultzmann. Their occurrence and diagnostic import are as follows:

1. *Red, Reddish-brown, and Brownish-yellow Semen.*—This coloration is usually due to the presence of blood. The blood may come from the posterior urethra or from the seminal vesicles, if either are acutely inflamed. Blood from the posterior urethra is usually not intimately mixed with the semen, and, if observed on the linen, the stain is spotted and streaked with blood. When the blood originates in the seminal vesicle it is more intimately mixed with the semen, and the coloration of the seminal spot is uniform. During the acute stages of gonorrheal posterior urethritis and seminal vesiculitis, bloody emissions are very frequent. Later on the blood appears mixed with pus; the seminal stains then have a greenish-yellow or yellow color, according to the relative quantity of blood and pus. In most cases bloody emissions cease after a few weeks; in some cases the condition may last for years unless properly treated. Tuberculosis and cancer of the prostate may also cause the semen to be blood-stained.

2. *Yellow Semen.*—A yellow coloration of the semen, sometimes yellowish-green, is due to the presence of pus. When the pus comes from the poste-

rior urethra the stain will be irregularly streaked and spotted with yellow; when from the seminal vesicles, uniformly yellow. The latter are seen in cases of chronic inflammation of the seminal vesicles, usually of gonorrheal origin.

3. *Claret-red and Violet Semen.*—These discolorations are due to the presence of indigo. The fresh semen is of a violet-gray color. Under the microscope many crystals of blue indigo may be seen. A red modification of indigo produces a claret-red color which may easily be confounded with blood. The microscope will show the presence of indigo crystals, and a chemical test the absence of blood. These stains are more evenly colored than those due to the presence of blood. These discolorations are rare. They have been observed in neurotic individuals. The semen is otherwise normal.

4. *Brown Semen.*—This discoloration is observed in the semen of men who are intensely jaundiced.

Oligozoöspermia.—A diminution in the number of spermatozoa is often observed after gonorrheal epididymitis. The inflammatory exudate obstructs the caliber of the vas deferens, and if the process ends in the formation of cicatricial tissue the lumen of the duct may be permanently closed. If both sides are affected the individual is rendered temporarily or permanently sterile. The intensity of the inflammation does not appear to be a measure of the probability of such permanent sterility. Thus we see men who have had numerous attacks of epididymitis on both sides, and who yet furnish semen containing abundant spermatozoa. In other cases the inflammation may be so slight that the patients have only a trifling amount of pain in the epididymis and along the cord, with scarcely palpable enlargement of the lower end of the epididymis, and yet they may be rendered permanently sterile. In some cases the passage is not occluded, but narrowed. In these the number of spermatozoa may be simply diminished. In some of them the spermatozoa are alive and active, in others we see only a few dead spermatozoa in each microscopic field. In addition there will be numerous pus cells and spermatin crystals. The history of these cases is often as follows: The patient suffers from a posterior urethritis, and sometimes, in addition, from a seminal vesiculitis. He furnishes at first blood-stained semen, and later semen containing much pus. Upon the advent of double epididymitis the number of spermatozoa in the semen will rapidly diminish, and the few remaining will be found dead. Soon even these will disappear, and the semen will consist of a fluid which may resemble normal semen in appearance, but under the microscope no spermatozoa will be seen. There will be pus cells, blood cells, spermatin crystals, granular detritus, epithelia, colloid granules, and occasionally indigo crystals. These men are temporarily or permanently sterile. I have had a number of such cases under observation throughout a series of years. In some of them spermatozoa reappeared after six months; some have remained permanently sterile. In one case spermatozoa reappeared after eighteen months. I have never seen them reappear after two years or more. Tuberculosis and cancer

of the lower genito-urinary tract may produce a semen poor in spermatozoa, and later on their total disappearance.

Inflammation of the Seminal Vesicles—Seminal Vesiculitis.—Inflammation of the seminal vesicles may be simple, gonorrheal, or tuberculous. The gonorrheal inflammation may be associated with mixed infection and the formation of abscess. The tubercular form is often associated with tuberculosis of the prostate and epididymis. The gonorrheal variety is much the most frequent.

Simple Catarrhal Inflammation of the Seminal Vesicles.—Simple catarrhal inflammation of the seminal vesicles is believed to occur, and to be associated, with dilatation of the vesicles. The condition is believed to result from an unhygienic sexual life, sexual excesses, masturbation, or prolonged sexual excitement without gratification. These patients are usually neurotic and neurasthenic subjects. They often have a congested and oversensitive posterior urethra, sometimes a slight degree of catarrhal posterior urethritis. In some of these cases the secretion of the prostate is increased in amount, and the individuals observe that after urination, during straining at stool, and during sexual excitement a certain quantity of opalescent, sticky fluid escapes from the meatus. This fluid they usually believe to be semen. They consider that they are suffering from constant seminal losses, or, as they call it, spermatorrhea. In this idea they are sometimes encouraged by reading quack medical literature. They are often partly impotent, and have premature ejaculations and other disturbances of the sexual function. They may complain of pain or of a sense of fullness in the perineum; of pain in the sacrum and of abnormal sensations in the glans penis and testes. They often have frequent urination and slight ardor. Upon rectal examination the seminal vesicles are found tender, enlarged, and dilated.

Gonorrheal Inflammation of the Seminal Vesicles.—Gonorrheal inflammation of the seminal vesicles may be of a mild or severe type, and either acute or chronic. It is probable that a large proportion of cases of acute gonorrhea have, associated with a posterior urethritis, an inflammation of the seminal vesicles, mild in degree, and not attended by any marked signs or symptoms. In these cases the involvement of the vesicles usually passes unnoticed, and gets well of itself. In another and much smaller group of cases the invasion of the vesicles is of a fairly severe type, and gives definite signs and symptoms. The condition may get well under appropriate treatment, or become chronic, or eventuate in the formation of an abscess. The signs and symptoms of acute seminal vesiculitis do not differ much from those of acute gonorrheal posterior urethritis and prostatitis. The patients suffer from painful and frequent urination. They have frequent, painful, and often bloody, nocturnal emissions. Defecation is painful. In some cases there is a rise of temperature. There is burning, throbbing pain in the perineum and rectum. The urine is purulent, and has the characters observed in acute posterior urethritis. Upon rectal examination the prostate will be found swollen and tender, and one or both vesicles will be found swollen, tender, and moderately hard. *If*

the contents of the seminal vesicle be expressed during this acute stage the patient's condition will be rendered much worse. The prostatitis and posterior urethritis will be aggravated; an attack of epididymitis will often follow.

Chronic Gonorrheal Inflammation of the Seminal Vesicles.—Many cases of acute inflammation are followed by a chronic form. One of the most marked characters of this type is the tendency to repeated attacks of epididymitis. The local and general symptoms are fairly marked, though they vary somewhat in different cases. These patients are nearly always sexual neurasthenics. They may have imperfect erections; they usually have premature ejaculations, and the orgasm may be painful. The semen usually contains blood, or blood and pus in an even mixture. There is usually a chronic posterior urethritis, and recurrent attacks of anterior urethritis are the rule. The patients complain of pain of a neuralgic character, referred to the sacrum, the perineum, the rectum, the testes, the inner surface of the thighs, and the hip. Much importance has been given to this last symptom by certain observers. Pain during defecation is common. In the early stages of the disease some of these individuals have a marked irritation of the sexual sphere. In some cases there is a marked desire with partial impotence. Some of these patients, on the other hand, are able to copulate with great frequency, so that for a time their exploits excite wonder and admiration. Sooner or later, however, though the sexual desire may continue, the power to gratify it diminishes, and may finally be entirely lost. In these chronic cases physical examination will discover the vesicles enlarged, thickened, and tender, sometimes markedly dilated. The expressed secretion will contain pus, and sometimes blood.

Abscess of the Seminal Vesicle.—In the course of an acute or chronic seminal vesiculitis, pyogenic infection with abscess formation may occur. The signs and symptoms resemble those of prostatic abscess; but it is to be borne in mind that abscess of the vesicle may rupture into the peritoneum with fatal results, or into the bladder or rectum, or into both, with the production of a recto-vesical fistula. The symptoms of a beginning abscess are those of sepsis—namely, a rise of temperature, a rapid pulse, a leucocyte count characteristic of suppuration, prostration, etc. Locally the patients suffer from painful and frequent urination, painful defecation, and burning, throbbing pain in the perineum, rectum, and sacral region. Rectal examination will disclose a tumor on the anterior rectal wall, above the prostate, as large as a goose egg, which may fluctuate, or a diffuse inflammatory induration above the prostate, extending beyond the reach of the finger, and without definable limits.

Tuberculosis of the Seminal Vesicles.—Tuberculosis of the vesicles is seldom observed as a primary focus of infection, but is a frequent accompaniment of tuberculosis of the epididymis and prostate. The vesicles become enlarged and nodular. Later on there is softening with the formation of tuberculous abscesses. These may rupture through the rectum, or into the bladder, or through the skin of the perineum. The diagnosis is usually simple, on account of the evident tuberculous disease of other portions of the genito-urinary tract.

CHAPTER XXXVI

THE SCROTUM, TESTIS, AND SPERMATIC CORD

ANATOMICAL REMARKS

The Scrotum

The scrotum hangs between the penis and the perineum. It is a somewhat pear-shaped bag of skin, narrower above, broader below. It exhibits a median vertical furrow between the inclosed testes. Nearly in the median line a narrow, white ridge can be seen upon the skin—the raphé—representing the line of fusion between the two halves of the originally divided scrotum. The line is continued forward on to the penis and backward on to the perineum. Upon either side are pear-shaped prominences corresponding to the testes. The two halves of the scrotum are not quite symmetrical, since the left testis hangs lower than the right. The raphé is directed from above downward a little to the right of the median line.

The *skin* of the scrotum is thin, soft, and translucent. It is very vascular, and when stretched numerous delicate veins can be seen in its substance. The skin exhibits notable brown pigmentation, and contains thinly scattered hairs as well as numerous sebaceous and sweat glands. The glands are visible as whitish granules within the skin. On account of the presence of the *dartos tissue*, consisting of unstriped muscle fibers, the skin of the scrotum is smooth or wrinkled, according to the relaxed or contracted condition of this muscular layer. The wrinkles or folds are transverse, and extend from the raphé laterally, concave upward, to the back of the scrotum. Under the influence of cold, mechanical irritation, sexual excitement, or other strong emotion, the muscle fibers contract, the wrinkles become more marked, and the entire scrotum shortened so that it tightly incloses the testes. Under the influence of heat, debility, and old age the scrotum is relaxed, and becomes smooth and longer. The raphé represents the line of union between the halves of the scrotum, and is continued dorsad as a septum, separating the scrotum into two sacs. Thus each testis with its coverings is lodged in a separate chamber. The wall of the scrotal sac consists of the skin and the dartos tissue. The latter contains unstriped muscle fibers running vertically, and is intimately adherent to the former. On account of this intimate connection, transverse wounds of the scrotum gape widely, resembling a loss of substance. The skin of the scrotum is very elastic. Exudates, hernia, and tumors may distend it to enormous

size. Owing to its extreme thinness the skin of the scrotum readily becomes necrotic from mechanical and chemical insults, and from heat, cold, and infection. The scrotum is attached to the coverings of the testis and spermatic cord by a very loose meshwork of connective tissue, so that effusions and exudates readily accumulate in this space in front of the testis. Behind, the connection is firmer. Such accumulations, however, after they reach a certain size, spread upward on to the abdominal wall, or backward into the perineum. The scrotum is very vascular. Its blood supply is derived from the external

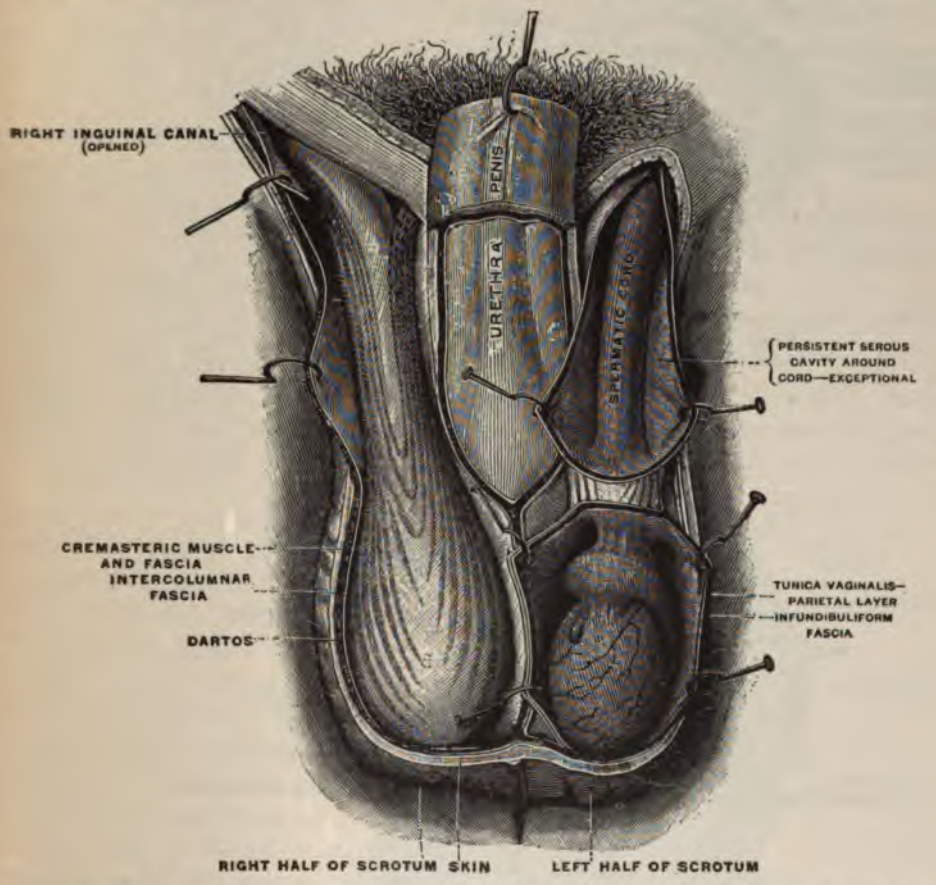


Fig. 235.—The Scrotum. On the left side the cavity of the tunica vaginalis has been opened; on the right side only the layers superficial to the cremaster have been removed. (Woolsey, Gerrish, Testut.)

pudic and the superficial branch of the internal pudic arteries. There is a free anastomosis between the two halves of the scrotum, and also at the root and base of the scrotum, between its vessels and those of the testis and cord. The lymph vessels of the scrotum empty into the superficial lymph nodes of the inguinal region.

The Testis and Spermatic Cord

The spermatic cord and testis are united by their coverings into a bundle—slender above, at the external ring, almost wedge-shaped below—corresponding to the situation and shape of the testis. The attachments of the testis and cord to the scrotum are for the most part loose, so that upon incising the scrotum it is very easy to enucleate the testis without the use of cutting instruments except at its lower pole, where it is attached to the bottom of the scrotum by the *scrotal ligament*. This structure represents the remains of the *gubernaculum testis*, a remnant of a fetal structure. The *infundibuliform fascia* (internal spermatic fascia) is also adherent to the posterior border of the testis and to the scrotum at this point. Even this attachment is not very firm, since by con-

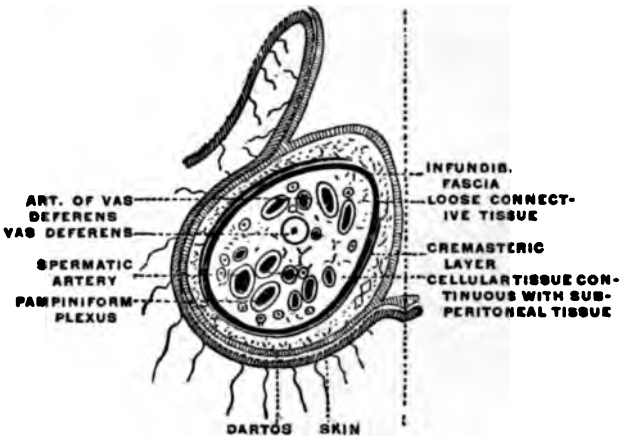


Fig. 236.—Transverse Section of the Right Spermatic Cord. (After Woolsey.)

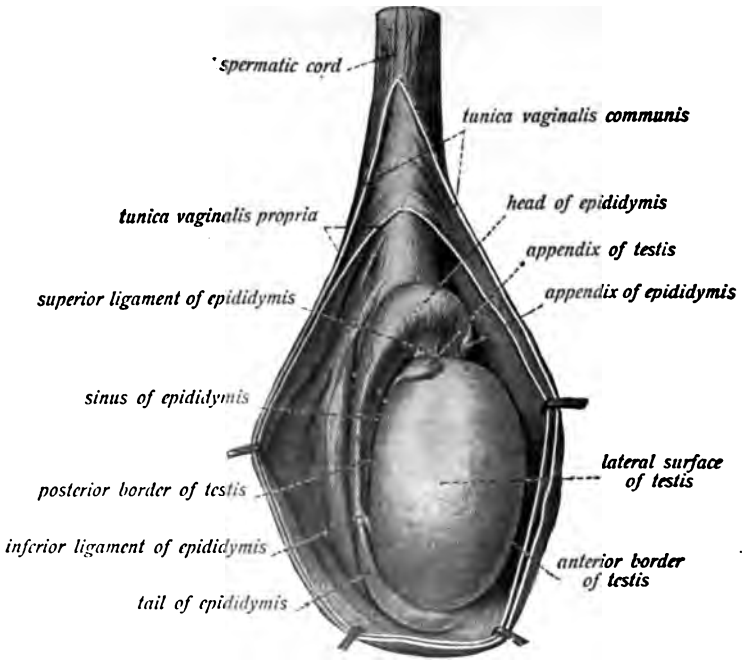


Fig. 237.—The Testis Seen from the Side. (Watson and Cunningham, after Sobotta.)

siderable force the testis may be dislocated on to the pubes into the perineum or groin.

The Coverings of the Cord and Testis.—*The Cremasteric Layer.*—The cremaster consists of voluntary muscle fibers, continuous above with the internal oblique muscle. It forms an incomplete muscular sheath for the cord and testis, a sort of sling, arranged in separate arched bundles bound together and covered by a thin layer of connective tissue at the sides and in front of, but not behind, the cord and testis. The contraction of the cremaster, under control of the will, raises the testis in the scrotum. Under strong sexual excitement the testes are drawn well up to the abdominal ring, so that the contracted scrotal sac appears empty. A similar contraction is observed in attacks of renal colic. The contraction in this case is usually limited to the affected side. The cremasters may be made to contract by scratching the skin of the groin (the cremasteric reflex).

The Infundibuliform Fascia.—The infundibuliform fascia corresponds with the same fascia in the groin. Together with the remains of the gubernaculum testis, it anchors the testis at the *lower part of the scrotum*; thus effusions into the tunica vaginalis testis may be safely tapped in front and through the upper part of the tumor.

Loose Areolar Tissue.—Loose areolar tissue, continuous with the subperitoneal connective tissue, connects the infundibuliform fascia with the tunica vaginalis and unites all the other structures of the cord into a bundle. The infundibuliform fascia, together with this loose connective-tissue layer, was described by Cooper, and is known as the *fascia propria* of Cooper. It was noted by him that these layers became firm and thickened in ancient and large herniæ. "Besides the (external) cremaster, two collections of unstriped muscle fibers are known as cremaster muscles, one of them in the cord (internal cremaster), the other in the subserous layer (middle cremaster)" (Woolsey).

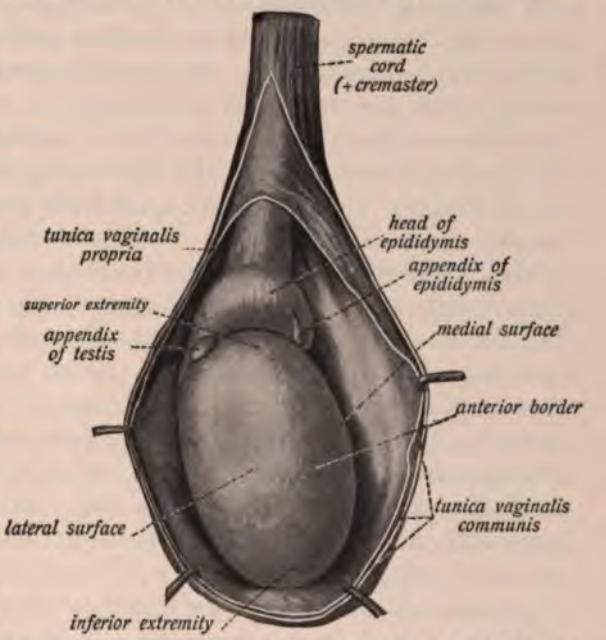


FIG. 238.—THE TESTIS AND ADJACENT STRUCTURES VIEWED FROM IN FRONT. (Watson and Cunningham, after Sobotta.)

The Testis.—POSITION.—The testicles hang suspended by their cords in the lower part of the scrotum, the left somewhat lower than the right. They are freely movable in the scrotum, and readily slip out of the way of danger when

pressed upon. The testis hangs so that its long axis is not exactly vertical. The upper pole is directed somewhat forward and a little outward.

Size.—The testis is on the average 1½ inches in length, 1¼ inches in depth, and rather less than an inch in thickness. Its weight is from 5 to 8 drachms. In childhood the testis remains small, but grows very rapidly to its full size at puberty. If one testis is congenitally absent, the other increases in size beyond the normal. If one testicle is lost during early manhood, the other may undergo hypertrophy. I have seen men whose testes were much larger than the average, but I do not know whether they were unusually active sexually or not.

Consistence.—The consistence of the testis is uniformly firm and elastic; firmer in strong, well-nourished men, softer in feeble individuals and the aged. Continence and repeated sexual excitement render the testes firmer. The surface of the testis is smooth; any inequality suggests disease.

Development.—In early fetal life the testis is developed in the abdominal cavity from the tissues of the genital ridge, and afterwards becomes connected with certain of the tubules of the Wolffian body (epididymis). It comes to lie behind the peritoneum at the level of the lower pole of the kidney, opposite the second lumbar vertebra. It sometimes possesses a short mesentery (mesorchium). To the lower end of the testis is attached a bundle of unstriped muscle fibers (the *gubernaculum testis*). These pass downward; some of them are attached to the internal abdominal ring, others to the bottom of the scrotum. Traction upon the testis by this structure has been thought to account for the descent of the testis. There are, however, but few facts in support of this supposition, the causes of the descent being really obscure. The testis differentiates itself as a distinct organ during the second month of pregnancy. During the third month it begins to descend and reaches the internal abdominal ring during the sixth month. During the following two months it passes through the inguinal canal, accompanied by a covering of the layers of the abdominal wall, including the pouch of peritoneum (processus vaginalis), which subsequently comes to form the tunica vaginalis testis. At the eighth month it reaches the external abdominal ring, and at birth has descended to the bottom of the scrotum. This situation, then, is a sign of the maturity of the fetus, though not absolute.

Abnormalities in the Descent of the Testis.—The testis may be arrested in its descent at any point in the abdomen, at the internal ring, in the inguinal canal, or at the external ring. Testes retained at the external ring usually descend completely before puberty; those arrested in the canal may do so. When the testes do not emerge from the canal, the condition is known as *cryptorchism*; if but one testis descends, as *monocryptorchism*. One testis may remain totally undeveloped; such an individual is a *monorchid*. If both testicles are absent or rudimentary, the individual is an *anorchid*. These last are usually feminine in appearance, and have an undeveloped penis. A *retained* testis is usually, but not always, *atrophic and functionless*. In certain

cases the testis may be absent, and yet an epididymis and vas deferens may descend to the bottom of the scrotum. A testicle may be present in the abdomen, but no epididymis or vas. In these no descent takes place. The causes for failure of descent are for the most part obscure. Such failure may well be due to undue shortness of the Wolffian duct (vas deferens) during embryonic life. It has also been attributed to peritoneal adhesions between testis and other pelvic viscera or intestine, and to interference by the aponeurosis of the external oblique muscle. Failure of descent is better explained by assuming a reversion to a lower type, since in many animals the testis remains permanently in the abdomen, and in others only descends during the season of rut.

THE COVERINGS OF THE TESTIS.—The testis is covered by its *tunica propria*, or *tunica albuginea*, and by the *tunica vaginalis*.

Tunica albuginea.—The tunica albuginea is a dense white layer of fibrous tissue which invests the organ, sends prolongations into its interior forming spaces for the lodgment of the glandular substance, and forms the *mediastinum testis* posteriorly and above, through which the blood-vessels pass to and from the testis and the straight tubules emerge carrying the spermatozoa to the epididymis. The tunica albuginea is tough and unyielding, so that sudden increased intratesticular tension is accompanied by severe pain, much greater than is true of the epididymis. Thus, orchitis is more painful than epididymitis. When the tunica is incised, testicular substance protrudes through the gap. If dirty or infected, or if the wound be old, it may be mistaken for granulation tissue, and upon this assumption has been many times curetted away or pulled out. The entire testis has thus been ignorantly removed. An acute abscess or other inflammatory process which ruptures may, by increased tension, cause the extrusion of the entire substance of the testis.

Tunica vaginalis testis.—The tunica vaginalis is a closed serous sac surrounding the testis almost completely. It represents the remnant of the processus vaginalis. Along the posterior border at the line of attachment of the epididymis and at the insertion of the gubernaculum at the lower pole the investment is incomplete. The visceral layer is reflected from the testis on to the epididymis laterally, covering it in part. Mesially the reflection passes directly into the parietal layer without including the epididymis. Normally, parietal and visceral layers are in contact, only enough serous fluid being present for lubrication. An accumulation of serous fluid in the sac constitutes a hydrocele. Along the uncovered posterior border of the testis the efferent tubules emerge to the head of the epididymis. Below, the blood-vessels pass to and from the testis, and at the lower pole the gubernaculum is attached. Normally, the entire canal of the processus vaginalis above the testis is closed at or shortly after birth. Its walls atrophy to a slender fibrous cord, sometimes traceable as far as the internal abdominal ring to end in a dimple on the peritoneal surface at this point. In some cases the canal remains patent throughout, encouraging the formation of a congenital hernia and constituting,

if fluid accumulates in the sac, a congenital hydrocele. In other cases the vaginal process is closed above and below, but remains open at one or more intermediate points, constituting a monolocular or multilocular encysted hydrocele of the cord respectively. Hydrocele of the canal of Nuck in females has a similar origin.

The anatomy of the secreting substance of the testis is not important from a diagnostic point of view, and is consequently omitted.

THE EPIDIDYMIS.—The epididymis is applied to the testis along its posterior border, and overlaps it slightly at the top and laterally. It begins above as a larger part—*the globus major*—which receives the efferent tubules from the testis (vasa recta); these dilate and collect into convoluted cones (coni vasculosi), which empty into the single canal of the epididymis whose convolutions form the central part or body of the organ. Below is the *globus minor, or tail of the epididymis*, beyond which the canal becomes thick-walled and firm and is known as the *vas deferens*. The body of the epididymis is but loosely attached to the testis, and is movable upon it, possessing a short meso-epididymis, made up of the two visceral layers of the tunica vaginalis. The recess thus formed between the testis and epididymis is known as the *digital fossa*. The tail, or globus minor, of the epididymis reaches almost to the lower border of the organ. It is slightly thicker than the body, and is not invested by the tunica vaginalis. It ends in the vas deferens.

THE ARTERIAL SUPPLY OF THE TESTIS.—The arterial supply of the testis is derived from the spermatic artery, a branch of the aorta, with an additional, though much smaller, supply by anastomosis with the artery of the vas. The veins enter the spermatic plexus.

THE LYMPHATICS.—The lymphatics enter the lumbar lymph nodes, *not* the lymphatics of the groin.

THE NERVES OF THE TESTIS.—There is a close association between the nerves of the spermatic plexus which accompany the spermatic artery and the abdominal sympathetic ganglia through the renal and aortic plexuses; consequently, injuries of the testis may be followed by severe *shock*, faintness, nausea, prostration, etc. The nervous connection mentioned also explains the pain felt in the testis during attacks of renal colic. The so-called "testicular sensation," of sickness and faintness when the testis is lightly squeezed, is sometimes a valuable diagnostic aid in differentiating between tumors and inflammatory swellings of the testis and epididymis, as well as in finding the testis in other pathological conditions of the scrotum.

FETAL REMAINS.—Certain relics of embryonic life are found in connection with the testis, and are interesting from a surgical point of view, since they may give rise to cystic tumors. (See Cysts of the Testis.) They are as follows:

1. *The Hydatids of Morgagni.*—Two structures are known by this name: (*a*) A pediculated, serous sac, containing fluid and attached to the globus major; sometimes absent. (*b*) "A constantly present, sessile, flattened, and

often lobulated structure, containing in its center a canal which may end blindly, or in a seminiferous canal. The sessile hydatid is attached to the upper end of the testis in front of the globus major, and represents the end of the duct of Müller; hence it is homologous with the fimbriated extremity of the Fallopian tube.

2. *The Paradidymis, or Organ of Giraldes.*—In adult life it consists of a single tubule, probably derived from the Wolffian body, which is blind at both ends or connected at one end with the tube of the epididymis or the rete testis. It appears as a yellowish-white patch, which lies outside the parietal layer of the tunica vaginalis, on the lower part of the spermatic cord, in front of the spermatic plexus and posterior to the globus major" (Woolsey).[1]

3. *The Vasa Aberrantes.*—These are convoluted, blind canals in the epididymis. There are usually two—one connected with the head, the other with the tail of the epididymis.

The Spermatic Cord.—The structures included in the spermatic cord form a bundle about the size of an adult little finger. They are the vas deferens, its artery, the spermatic artery, the veins accompanying these arteries; the sympathetic nerves running with the arteries; the internal cremaster fibers; the remains of the processus vaginalis (the habenula of Scarpa). These structures are all bound together, and inclosed by a layer of connective tissue containing fat. The several components may be divided into an anterior and a posterior group, but loosely connected, while the individual members of each group are more firmly adherent. The anterior group contains the vessels and nerves of the testis and epididymis. The posterior group contains the vas deferens, with its vessels and nerves. In each group are included fibers of the internal cremaster. In the anterior group there is some fat, in the posterior group but little; around the vas deferens there is none. The vas lies at its commencement behind and to the inner side of the epididymis, and maintains the same relation to the structures of the cord throughout its course. The vas is readily palpated above the testis as a firm cylinder about the size of a crow quill. It is readily separated from the structures of the anterior group. The *veins* of the spermatic cord or pampiniform plexus are five or six in number. They lie in front of the vas and surround the spermatic artery. They are poorly supplied with valves. The veins of the left side empty into the left renal vein at a right angle; those of the right side into the vena cava at an acute angle—i. e., in the direction of the blood stream. The preponderance of varicocele upon the left side has been supposed to be due in part to this fact. The veins of the plexus anastomose freely. In the inguinal canal the veins unite into three or four trunks, and these finally into a single trunk accompanying the spermatic artery in the abdomen. *In operating for varicocele it is important not to include the veins accompanying the vas deferens in the ligature.* The spermatic artery is best avoided, yet its inclusion in

[1] Woolsey, *loc. cit.*, page 416.

the ligature does not destroy the testis, since its anastomosis with the artery of the vas and those of the scrotum will provide sufficient blood. When the open operation is done (preferred by general surgeons) the veins may be cleanly exposed, ligated, and excised without the risk of including the genito-crural nerve which supplies the cremaster muscle.

INJURIES OF THE SCROTUM

Contusions of the Scrotum.—Injuries of the scrotum, from blunt violence such as blows, falls, kicks, etc., are frequent. Ecchymosis is often marked. The scrotum on one or both sides swells, becomes black and blue, smooth and glazed. The discoloration may spread to the perineum, pubes, groins, and thighs. Usually, under rest, cold and support, the effused blood is rapidly absorbed. In a few cases a large hematoma forms in the space between the dartos and the proper coverings of the cord and testis. If the scrotum is abraded, such a hematoma may become infected. Therefore, contusions of the scrotum should be treated by disinfection of the skin and the application of a sterile dressing as a preliminary to other measures.

The signs of infection are plainly evident from increased swelling and firmness of the tumor, and by the appearance of redness, pain, heat, and tenderness, together with constitutional symptoms. Noninfected contusions of the scrotum are but slightly painful. If in doubt as to the condition, the use of an aspirating needle and cultures made from the fluid should clear up the diagnosis.

Open Wounds of the Scrotum.—Accidental wounds of the scrotum are contused and lacerated; less often incised, punctured, and gunshot wounds. Wounds of the scrotum usually bleed freely. Horizontal wounds gape, simulating loss of substance. Prolapse of the testis may occur, and the cord may be more or less compressed by the wound edges. Wounds with loss of substance never demand castration. The testes cover themselves rapidly with skin. Nature may be aided by suitably placed sutures; later by skin grafting.

Gunshot Wounds of the Scrotum.—Gunshot wounds of the scrotum are fairly common in warfare. The testis or cord are wounded in about two thirds of the cases.

DISEASES OF THE SCROTUM

Intertrigo.—Intertrigo of the scrotum and thighs is common in male children when not kept clean, and is sometimes observed in stout men. The opposed surfaces become red and tender, sometimes excoriated. The subjective symptoms of burning and itching are present.

Eczema marginatum.—A parasitic disease, due to the same parasitic fungus which causes ordinary ringworm—i. e., trichophyton. The lesion is slightly modified by its situation, and may be converted into a moist eruption. The threads and spores of the fungus can usually be identified under the micro-

scope from scrapings made at the advancing edge of the lesion. The eruption consists of round, crescentic, or semicircular patches of reddened skin upon the thighs and scrotum, where they lie in contact. The border of the lesion is scaly, and may exhibit excoriations, crusts, and minute pustules. The patches advance along a wavy line at the periphery. The central and older parts heal and become pigmented. Itching and burning are the subjective symptoms. The treatment is antiparasitic. Relapses are common.

Pediculi pubis (Crab Lice).—The skin of the pubes is the home of the crab louse, though they are found on any of the hairy parts of the body except the scalp. The axillæ, the chest, and the scrotum are frequent sites. The eyelids and eyebrows of neglected children are often infested with them. In these cases, owing to the situation, their presence will escape notice except upon careful examination.

The louse resembles a crab in shape. It is 2 mm. long, 1.4 mm. wide. The head is small, and separated from the thorax by two constrictions. The thorax, broader than the abdomen, passes into the latter without constriction. The abdomen is heart-shaped. Its borders exhibit small nipple-shaped, hairy projections. Legs: Anterior pair of legs, soft and tapering. The two posterior pair, strong and thick, are armed with powerful, hooked claws. The ovoid nits are cemented to the pubic hairs.

Though the louse is quite large enough to be seen by the naked eye, it lies flat upon the skin, and when young differs but little from the integument in color. The older lice develop a bluish or brownish pigment. They are thus more easily seen.

Crab lice are acquired from infected water-closet seats, from blankets, sheets, clothing, and from coitus with a person already infested. As usually observed, the lice are stationary. They lie flat, with their claws buried in the skin, are disinclined to move, and appear to be of a sluggish disposition. If, however, one of them is dislodged with a toothpick and placed upon the naked skin of the hypogastrium, he may be watched hurrying back to cover in a surprisingly active manner. The symptom produced by crab lice is itching. In a few cases I have seen the skin reddened and excoriated from scratching, and a consequent inflammatory swelling of the inguinal lymph nodes.

Much the most rapid and efficient treatment for these pediculi is the application of tincture of delphinium and ether, equal parts. Mercurial ointment is dirty, but if its application be repeated several times, at twenty-four-hour intervals, it is efficient.

Acute Inflammatory Processes of the Scrotum.—Acute suppurative and necrotic inflammations of the scrotum may follow infected wounds of the scrotum and ulcerative processes of the scrotum, penis, perineum, and ischiorectal fossa. They are characterized by a tendency to progressive phlegmonous infiltration followed by necrosis and gangrene, by profound septic poisoning, and constitutional depression. Among special causes may be mentioned diffuse suppurative inflammation of the corpora cavernosa penis, rupture of the ure-

thra with urinary infiltration, tight stricture of the urethra with ulcerations behind the stricture, and infection of the periurethral structures, with or without infiltration of urine, suppuration of the testis, and purulent inflammation of the tunica vaginalis testis. The phenomena of phlegmonous inflammation and gangrene of the scrotum are described under Urinary Infiltration.

Edema.—Edema of the scrotum is common in various forms of cardiac and renal disease. Interference with lymphatic circulation by chronic inflammatory processes of the lymph nodes, and as a result of the extirpation of the lymph nodes of both groins, may be mentioned as local causes. The signs and symptoms are painless swelling of the scrotum without evidences of inflammation. The skin of the scrotum becomes smooth, tense, shiny, and boggy to the touch. The diagnosis is to be made by the absence of the signs of inflammation and by finding a constitutional or local cause.

Erysipelas.—Erysipelas of the scrotum is characterized by its sudden onset, by rapid swelling, profound constitutional depression, and a marked tendency to end in gangrene of the tissues. In the alcoholic, aged, and debilitated the prognosis is bad. (See Erysipelas.)

Elephantiasis of the Scrotum.—The pathology of elephantiasis due to Filaria sanguinis hominis is sketched under Elephantiasis of the Penis. In Egypt, India, Samoa, and other tropical lands the disease is very common. Isolated cases appear from time to time in New York. They are usually imported. The essential lesion consists of enormous thickening of the skin and subcutaneous tissues from a deposit of new-formed fibrous tissues, together with interference with the lymph current, as elsewhere described. In marked cases the scrotum increases to enormous proportions, and the suffering and discomfort are great. The scrotum may attain a weight of 30 to 50, even 150, pounds, so that the individual must carry it in a sling or wheel it on a barrow before him. The penis retracts into a cleft in the face of the tumor, so that the skin is continually irritated by decomposed urine. Excoriations and blebs form and rupture, and a chylous fluid escapes from the raw surfaces. Chylous urine is often present.

Extirpation of the inguinal lymph nodes of both groins may be followed by lymph edema and great enlargement of the scrotum.

Tumors of the Scrotum.—Sarcoma, lipoma, and fibroma of the scrotum, as well as their combinations, have been described.

Cysts.—Single and multiple serous cysts of the scrotum have been described by Jacobson and F. T. Brown.

Sebaceous Cysts of the Scrotum.—Sebaceous cysts of the scrotum are common. They are often multiple, and usually of small size. They form white, rounded elevations in the skin, usually near the middle line. The diagnosis presents no difficulties.

Dermoid Cysts.—Dermoid cysts of the scrotum occur in the middle line, near the back of the scrotum. They may be prolonged between the urethra

and rectum. They originate from fetal inclusions of the ectoderm during the formation of the perineum and the separation of the rectum from the urogenital sinus. They form rounded, tense, elastic, smooth tumors, with characteristic contents. (See also Sacrococcygeal Tumors, vol. iii.)

Angioma of the Scrotum.—A few cases of lymph and hemangioma have been described. In 1908 I removed a congenital cavernous angioma of the scrotum. The patient was twenty-six years old. The tumor had existed and grown steadily, though slowly, as long as he could remember. The mass of dilated vessels and trabeculated blood spaces was, when the patient stood erect, as large as two fists (see Fig. 239). The venous channels communicated with two large veins running into the perineum in the angle between the bulb of the corpus spongiosum and the rectum. By cutting beyond the edge of the tumor the bleeding was easily controlled.

Fig. 239.—Congenital Cavernous Angioma of the Scrotum. (New York Hospital, author's service.)

Cancer of the Scrotum.—Epithelioma of the scrotum is a rare disease in New York. It is said to be fairly common in England, where it has long been known as "chimney sweeps' cancer." Those who work in the manufacture of paraffin and other coal-tar derivatives suffer from the disease, not only upon the scrotum but also upon the backs of the hands and forearms. In all cases the disease appears to be due to chronic irritation of the skin. In the case of chimney sweeps of uncleanly habits, the soot accumulated upon the scrotum produces a chronic dermatitis. Warty outgrowths appear upon the scrotum. These become cracked and excoriated; gradually the base of the wart becomes thickened and hard, the surface of the wart breaks down, and later, deep typical epitheliomatous ulcers are formed, with elevated, hard edges and firm, infiltrated bases. In some cases cauliflowerlike growths develop. The discharge is thin, purulent, or bloody, its character being modified by the amount of infection and ulceration. Gradually the deeper structures are involved, until the testicles may be invaded and a large part of the scrotum lost. The lesions are often multiple, as might be expected from their causation. The course of the disease resembles that of the superficial epitheliomata of the face, but is rather more malignant. The progress is usually slow. The inguinal glands may long remain free. In some cases the testes and cords are finally

invaded; in these, infection of the lumbar glands may occur. In other cases the inguinal lymph nodes become cancerous at a rather early period. Death occurs from sepsis, exhaustion, and repeated bleeding.

The early *diagnosis* is to be made from the history of the occupation and the resulting chronic irritation of the scrotum, and finally from the gross and microscopic appearance of the lesion, here as elsewhere entirely characteristic.

Prognosis.—Early operation, including an excision of the scrotum wide of the disease and extirpation of the inguinal glands, offers a fair prospect of cure.

INJURIES AND DISEASES OF THE COVERINGS OF THE TESTIS

Effusions and exudates may take place within the common connective-tissue investment of the testis and cord or within the tunica vaginalis testis.

Injuries of the Testicular Coverings.—Contusions may be followed by extravasation of blood between the connective tissue and proper sheath of the testis or within the common sheath of the cord. The former are usually small and circumscribed; in the latter the hematoma may extend from the external ring to the testis. It may be sharply defined or diffuse. In some cases the blood also finds its way around the testis outside the tunica vaginalis. In this event the testis lies at the bottom of the tumor, its long axis horizontal. The source of bleeding is usually from veins, rarely from arteries.

Diagnosis.—The diagnosis depends upon the following data: There is a history of injury to the scrotum—either a contusion or sudden, strong traction upon the testis and cord. A tumor is rapidly formed in the region of the testis and cord. There is local pain and tenderness. If the tumor extends into the inguinal canal, it may be mistaken for a hernia. If the testis is found horizontal and at the bottom of the tumor, hernia can generally be excluded, though other signs should be sought for. The subsequent history of these hematomata is usually that of a rapid absorption of the effused blood. If a cystic tumor remains, it should be incised and the blood evacuated.

Hematoma of the Tunica vaginalis testis.—Hematoma of the tunica vaginalis testis is rarer than the preceding, though the two may coexist. It usually follows injury of a hydrocele. The tumor formed is sharply circumscribed, situated in the lower part of the scrotum, tense, fluctuating, not translucent. The testis cannot be distinguished by palpation. There is often severe pain. Marked constitutional depression, faintness, and vomiting point to an associated injury of the testis. The blood remains fluid for a long time, and is rarely completely absorbed. The condition usually eventuates in a hydrocele. Incision and evacuation of the blood is the surest method of cure. (See also Periorchitis Hemorrhagica.)

Acute Inflammation of the Tunica vaginalis testis—Acute Hydrocele—Acute Sero-fibrinous Periorchitis.—Acute inflammation of the tunica vaginalis testis

may follow injury, but is most often met with as a part of the lesion in acute gonorrheal epididymitis, occasionally as a complication of acute infectious diseases, typhoid fever, the exanthemata. The sudden invasion of the epididymis by tuberculosis may be associated with acute sero-fibrinous periorchitis. The cavity becomes distended by an exudate of serum containing leucocytes in moderate number and flocculi of fibrin.

Diagnosis.—Disregarding in this place the lesion of the epididymis, the signs and symptoms are sudden and very painful swelling of one side of the scrotum, with moderate redness and edema of the overlying skin. There is exquisite tenderness on pressure. Palpation reveals an ovoid, tense, smooth, fluctuating tumor in the position of the testis. If the serous exudate is considerable, and contains but little fibrin, the tumor may be translucent. If much fibrin is present, crepitation may be detected on palpation. A slight elevation of temperature is a very constant symptom. Under rest and suitable treatment the exudate is absorbed in ten days or so, or, in other cases, the disease becomes chronic, depending upon its causation. The amount of pain in these cases is often excessive. For the immediate relief of this symptom there is nothing so efficient as the aspiration of part of the fluid through a fine aspirating or hypodermic needle.

Purulent Inflammation of the Tunica vaginalis testis.—This condition may follow wounds of the tunica vaginalis. It may occur in the course of pyemia. It may follow severe mixed infection in the course of gonorrhea, as a complication of severe epididymitis or abscess of the prostate. Twice I have seen severe infection follow the tapping of a hydrocele with a dirty aspirating needle or trocar. One case resulted in a fatal pyemia, the other in phlegmonous inflammation and extensive sloughing of the scrotum.

The *symptoms* of purulent inflammation of the tunica vaginalis resemble those of the sero-fibrinous form, but are much more intense. In addition there are septic symptoms, more or less severe. If allowed to rupture, extensive, usually necrotic, infection of the scrotum follows. The treatment is early free incision and drainage.

Acute Hydrocele of the Spermatic Cord.—If a portion of the processus vaginalis has remained open into the abdomen or is closed off above and below, it may become acutely inflamed as the result of injury or of an infectious lesion of the genito-urinary tract. The disease is said to be more common in childhood, and is characterized by the sudden formation of a tender, painful, sharply bounded, tense, fluctuating swelling connected with the spermatic cord. The condition may be confounded with a strangulated hernia. Symptoms of intestinal obstruction are usually absent, though in the most severe cases vomiting and constipation may be marked symptoms. The tumor is always more readily movable than a strangulated hernia. If suppuration occurs there will be septic symptoms and the local signs of infection. An aspirating needle introduced into the mass will determine the character of the exudate.

HYDROCELE TESTIS, CHRONIC SEROUS PERIORCHITIS

Hydrocele, or the accumulation of serous fluid in the tunica vaginalis testis, is a very common disease. It occurs with great frequency in the tropics and commonly enough in temperate lands. It is observed at all ages.

Causes.—No cause can be assigned in a large proportion of cases. In some the condition is congenital, in many there is a history of injury. Antecedent inflammatory processes of the tunica vaginalis have existed in a certain proportion of cases. Many observers believe that, next to trauma, gonorrheal epididymitis is the most frequent cause. Such a causation in my own experience has been very rare.

Pathology.—The quantity of fluid varies within wide limits—from a few ounces to many quarts in old, untreated cases. The fluid is usually clear and of a pale straw color, occasionally of a greenish tinge, sometimes opalescent, sometimes blood-stained. Shreds of fibrin may be present. Microscopically, endothelial cells, leucocytes, and blood cells are found in varying numbers. Cholesterin crystals may be abundant in old cases. The reaction of the fluid is neutral or faintly alkaline. Its specific gravity is 1.020 to 1.024. It contains abundant sodium chlorid and alkaline carbonates, together with a notable quantity of albumin—about four per cent. The sac of a hydrocele may remain practically normal for a long time, provided it is not subjected to mechanical irritation. In old cases the wall of the sac is thickened, its inner surface rough, ridged, and dull. There may be adhesions between the sac and the testis. Localized areas of thickening, areas of hemorrhagic infiltration, and fatty degeneration are often observed. Calcareous plaques may develop in the sac wall. Very rarely the wall may be extensively covered with calcareous deposits resembling the walls of some ancient ovarian cysts. Minute cysts connected with the epididymis may rupture into the sac. The fluid may then contain spermatozoa. Concretions or floating bodies sometimes occur. They consist of masses of fibrin containing earthy phosphates and carbonates. They are usually of small size, and are supposed to be due to a deposit formed upon a small vegetation on the inner wall of the sac or testis which has broken loose from its attachment.

The Testis.—The position of the testis in reference to the bulk of the tumor varies slightly, according to the size of the hydrocele. If the accumulation is small the testis lies behind and rather above than below the middle of the tumor; if of medium size, the testis lies behind and near the lower pole. In very large hydroceles the distention greatly increases the dimensions of the lower part of the sac, and the testis lies behind and above the lower pole (Kocher). In large hydroceles the testis may undergo partial or total atrophy. In the former case the testis recovers if the hydrocele is cured.

Symptoms and Diagnosis.—In simple cases there is no diagnosis easier to make than that of hydrocele. While the tumor remains small it gives no symptoms, and rarely attracts the patient's attention. When he presents himself

for examination it has usually attained the size of a goose egg. The patient may believe that the swelling has appeared suddenly, whereas it has probably been growing for a year or more. The fluid accumulates gradually, but nearly always continuously, until it begins to produce symptoms from its size and weight. These are a sense of dragging in the groin and along the cord. There is sometimes discomfort from the pressure of the clothing upon the tumor, rarely irritation of the skin of the scrotum. If the hydrocele is very large, coitus may be interfered with. Urination may be uncomfortable.

Diagnostic Signs of Hydrocele.—The pear-shaped, ovoid, or, in large hydroceles, nearly spherical tumor occupies one lateral half of the scrotum. It is painless. The skin stretched over it, more or less tightly, is smooth, often shiny. Upon palpation the surface of the tumor is insensitive, smooth, tense, and elastic. If the tension of the sac is not too great, fluctuation can be detected. The tumor is irreducible. There is flatness on percussion. There is no impulse on coughing. The skin can be moved freely over the tumor. Signs of inflammation are absent. If the hydrocele is small the testis can often be made out on the posterior wall. If larger, the testicular sensation on pressure may locate the organ. The cord can usually be felt above the tumor, and the upper pole of the mass is, except in rare cases, sharply circumscribed. There is in ordinary cases no impulse on coughing. The tumor is translucent. The "light test" is made in the following way: The tumor is grasped from behind, raised above the level of the thighs, and the skin of the scrotum is gathered up and put upon the stretch. The end of a cylinder of metal, wood, rubber, or the like, about one inch in diameter and five or six inches long, is pressed firmly against one side of the tumor while a source of light—a candle, lamp, or electric bulb—is held near the opposite side of the scrotum. The examiner looks through the cylinder. If the sac contains clear fluid, light is transmitted through it readily. The direct light should be shut off from the eye by the hand, or a screen placed along the upper border of the scrotum. The examiner should hold the cylinder very firmly against the scrotum, lest light be admitted between the two. The examination is more satisfactory when made in a darkened room.

A small hard-rubber cylinder, containing a lighted electric bulb, may be held against the scrotum while the examiner views the tumor from the opposite side. This method also succeeds best in the dark. It is to be borne in mind that a hydrocele with a thick sac may not transmit light freely; that a hernia in a child may be translucent; that certain soft tumors may transmit light, notably myxomata; that a bloody effusion is opaque; that a hydrocele and a hernia may coexist.

Varieties of Hydrocele.—The varieties of hydrocele are: (1) Hydrocele communicans, communicating hydrocele, congenital hydrocele; (2) bilocular hydrocele; (3) infantile hydrocele; (4) inguinal hydrocele; (5) diffuse hydrocele; (6) encysted hydrocele of the spermatic cord; (7) multilocular hydrocele of the spermatic cord.

1. Congenital Hydrocele.—In this condition the processus vaginalis has failed to close, and remains open throughout from the peritoneal cavity to the bottom of the pouch surrounding the testis—i. e., the anatomical condition is that observed in congenital hernia. These hydroceles are usually observed during infancy. The communication with the abdominal cavity is usually small, and often closes spontaneously during boyhood. When the process of peritoneum remains open, but the testis fails to descend and remains in the inguinal canal, a collection of serous fluid in the peritoneal pouch constitutes the variety known as *inguinal hydrocele*. The physical characters of congenital hydrocele, and its differences from a congenital or other hernia, are as follows: In congenital hydrocele the testis is included in the ovoid or cylindrical tumor of the scrotum. The tumor is flat on percussion. In the recumbent position reduction may occur spontaneously, or the tumor may be reduced gradually upon gentle pressure, after which the testis becomes palpable. Upon resuming the erect posture the sac refills, *not suddenly but gradually*. There is a more or less marked impulse upon coughing. The sac, when filled, is translucent. A hernia containing intestine is reduced by manipulation suddenly. The reduction is accompanied by gurgling. Intestine is resonant upon percussion. During infancy the omentum does not extend low enough to enter the hernial sac.

2. Bilocular Hydrocele, Abdominal Hydrocele.—In these cases the sac occupies the scrotum, but extends also through the inguinal canal, to form a second sac between the peritoneum and the transversalis fascia. Thus there are two sacs—one in the scrotum, the other in the abdomen, communicating through the inguinal canal. The intra-abdominal portion may reach a large size. Bimanual palpation will discover that when the intra-abdominal tumor is pressed upon, the tension of the scrotal sac is increased, and *vice versa*.

3. Infantile Hydrocele.—The processus vaginalis is closed off from the cavity of the peritoneum, but remains open from the testis as far as or beyond the external abdominal ring. The signs and symptoms resemble those of congenital hydrocele, but the tumor is irreducible.

5. Diffuse Hydrocele.—We designate by this title a diffuse edematous infiltration of the tissues of the spermatic cord, resulting from the rupture of a hydrocele or of a spermatocele.

6. Encysted Hydrocele of the Spermatic Cord.—This is a hydrocele in a partly obliterated processus vaginalis. The sac lies above the testis, but closed off from the abdominal cavity. There may be one distinct sac surrounding the vas, or the sac may be constricted or obliterated at one or more points, so that two or more distinct cystic tumors are produced. The latter condition is the only one which properly merits the title of *multilocular hydrocele of the spermatic cord*. Encysted hydrocele of the cord is usually observed in children, occasionally in adults. It sometimes follows contusions of the cord. The signs and symptoms are the presence of one or more rounded, tense, cystic tumors, connected with the spermatic cord above and separate from the testis

and epididymis. The cysts are movable, and in some cases can be pushed into the inguinal canal, but not into the abdominal cavity. They are adherent to the vas deferens, which may be felt to move with the tumor. The cysts are translucent unless, as the result of injury, they become filled with bloody fluid. They are to be distinguished from spermatocele by the absence of spermatozoa from the aspirated fluid. The latter are, moreover, immediately connected with the epididymis. The symptoms produced are trifling unless the sac reaches a considerable size. If the cyst lies high up on the cord, it may slip in and out of the inguinal canal, and be pinched by the borders of the external abdominal ring. Encysted hydrocele of the cord must also be differentiated from a *hydrocele in an old hernial sac.* An empty hernial sac which has been shut off from the abdominal cavity by adhesive inflammation may be mistaken for a hydrocele of the cord or a hernia. The sac is translucent unless greatly thickened. The tumor is irreducible. Impulse on coughing is slight or absent. There is a history of a former hernia.

7. Multilocular Hydrocele of the Spermatic Cord.—Kocher classified the multiple cystic tumors of the spermatic cord into five groups: (1) Echinococcus cyst. (2) Spermatocele. (3) Encysted hydrocele of the cord, subdivided into loculi by adhesive inflammation. (4) Cysts of fetal remains (Müller's duct, mesonephros or Wolffian body, organ of Giraldes). (5) Cystic lymphangioma.

While some of the diagnostic signs of these various conditions will be found described in the following paragraphs, it must be said that the signs and symptoms of all are so much alike that in many instances a differential diagnosis will not be possible without incision. There is a tumor along the spermatic cord of varying extent. It is ovoid or cylindrical, translucent, rather boggy than tense. It may be partly reduced into the inguinal canal. There is a slight impulse on coughing. Boggy areas may alternate with areas of fluctuation. The tumor rather resembles on palpation an omental hernia than anything else.

Multilocular Hydrocele of the Tunica vaginalis testis and Cystic Tumors of the Epididymis.—In some cases of irritation of the tunica vaginalis an adhesive inflammation may lead to the formation of adhesions and connective-tissue septa between different portions of the sac. If, now, serous fluid accumulates, a compound or multilocular hydrocele may be formed. In other cases there occur within an ordinary hydrocele one or several pedunculated cysts, apparently originating in the pedunculated cystic hydatid regularly present. In other cases a cystic tumor is formed connected with the head of the epididymis, the latter containing spermatozoa. A second sac may sometimes be formed by a hernia of the tunica vaginalis between the testis and the epididymis.

Spermatocele and Other Cysts of the Epididymis.—Cysts connected with the epididymis may have several origins. Small cysts, containing serous fluid probably developed from the cystic hydatid, are not rarely found when operating upon the hydroceles of elderly men; they are of no clinical significance. Other and larger cysts, sometimes associated with ordinary hydrocele, some-

times occurring alone, develop in connection with the epididymis. Sometimes they contain spermatozoa and sometimes they do not. In the former case the cyst constitutes a spermatocele. These cysts of the epididymis arise in several ways. It is believed that the spermatoceles may be retention cysts of the efferent tubules of the epididymis, caused by obstruction of the ducts due to injury or to disease, as from gonorrheal epididymitis. On the other hand, they may originate from fetal remains—either the ductuli aberrantes or in the sessile hydatid of Morgagni. These two structures give rise to cysts connected with the tubules of the epididymis. Spermatozoa are found in the contents of the cysts unless the communication with the tubules of the epididymis is obliterated, when the spermatozoa may disappear. The paradidymis, or organ of Giraldes, which represents tubules derived from the Wolffian body or mesonephros, may also give rise to cystic formations. These cysts develop upon the vas deferens, behind the globus major of the epididymis and in front of the vessels. They contain a milky, turbid fluid, but no spermatozoa, since they communicate neither with the testis nor epididymis. The cysts which originate in the head of the epididymis may grow into the tunica vaginalis or between the testis and epididymis, sometimes upward along the cord. When the cyst grows downward between the testis and epididymis, the former is usually rotated so that its long axis is horizontal. The cyst and epididymis may lie above the testis. When a cyst projects into the cavity of the tunica vaginalis, and more especially when it is associated with a hydrocele, a diagnosis is scarcely possible without operation. In most cases the testis and epididymis, or at least their lower portions, may be made out below the tumor. They are much more closely connected with the testis than are hydroceles of the cord. In those which originate in the tail of the epididymis the tumor may lie below the testis, or the testis may be rotated by the weight of the tumor so that it comes to lie above it. The tumors are usually rounded or ovoid in shape, and of elastic consistence. They may be multilocular, with corresponding inequalities of surface. The wall of the cyst is usually soft and thin. In some cases it may become thickened—even the seat of calcareous degeneration. Puncture of the cyst and aspiration of its contents, with the discovery of spermatozoa, establishes the diagnosis of spermatocele. The color of the fluid is usually milky, or at any rate less clear than that of a simple hydrocele. The specific gravity is lower than that of hydrocele fluid—1.005, more or less, in the former as compared with 1.020 in the latter. The content of albumin is low—one half of one per cent as compared with four or five per cent in hydrocele fluid. Cysts of the epididymis are usually met with during middle age. They grow very slowly, but may after years attain a considerable size. Cysts containing a quart have been observed. The symptoms produced are not characteristic. After they have reached a certain size they may cause a moderate amount of uneasiness, referred to the testis and cord. They sometimes produce a degree of anxiety on the part of the patient, as do all affections of the testis.

PERIORCHITIS HEMORRHAGICA

A chronic inflammation of the tunica vaginalis testis characterized by a bloody effusion into that sac. The condition may follow injury to the testis with hematocele. It may result from injury to a hydrocele or from tapping or injecting a hydrocele. It sometimes occurs spontaneously, and is then associated with degenerative changes in the walls of the blood-vessels.

The *lesions* are the formation of new connective tissue in the tunica propria, resulting in marked thickening of that membrane; the occurrence of repeated hemorrhages into the cavity of the tunica vaginalis and into the substance of the tunica propria. In the early stages the surface of the tunica vaginalis is covered by a layer of granulation tissue containing numerous blood-vessels and blood spaces. No endothelial covering is demonstrable. The blood-vessels become gradually less frequent in the firm, fibrous tissue which constitutes the altered wall of the tunica propria. In advanced cases the surface of the membrane exhibits plaques and projecting masses of fibrous tissue of cartilaginous hardness. Deposits of lime salts occur in the thickened membrane. In some cases as isolated plaques, in others the entire testis and epididymis is surrounded by a dense mass of connective tissue containing an abundant deposit of calcareous material, and of stony hardness. In advanced cases the testis and epididymis may undergo total atrophy from pressure and interference with blood supply. A sclerotic condition of the arteries is a part of the lesion, especially when it occurs in elderly men.

In another group of cases, sometimes distinguished by the title *proliferating periorchitis*, there is in addition an invasion of the testis itself by masses of new-formed fibrous tissue, together with the formation of vegetations and of masses of similar tissue upon the surface of the visceral and parietal layers of the tunica vaginalis.

The character of the exudate in the former group of cases varies. It may be sero-fibrinous, it may be almost pure blood, or, in older cases, it may consist of crumbly masses of brownish or reddish material made up of degenerated fibrin and blood pigment. Hematogenous infection of the sac and suppuration is not a very rare accident.

Causation.—In many cases there is a history of injury, usually to a pre-existent hydrocele, where the tunica vaginalis is already in a state of chronic inflammation. It may follow tapping of an ordinary hydrocele or tapping and the injection of carbolic acid or iodin. In some cases the disease appears to arise spontaneously in aged or elderly men, and in these the cause is probably localized arteriosclerosis.

Symptoms.—Following an injury to a hydrocele or spontaneously, the scrotum rapidly or slowly swells, with or without marked pain and discomfort, according to the rapidity of the bleeding. After an interval another hemorrhage occurs, producing a further increase in size of the scrotal tumor. In other cases the disease is steadily progressive, without sudden exacerbations.

Physical Signs.—The physical signs differ from those of ordinary hydrocele. The tumor is harder. It is rarely translucent. In hydrocele the position of the testis can often be made out because it feels firmer than the rest of the mass. In periorchitis hemorrhagica, on the other hand, the testis, if felt at all, will be softer than the rest of the tumor. The serious factors in the disease are the almost certain destruction of the testis in advanced cases and the danger of suppuration. In some cases the bleeding may be so profuse as to demand immediate surgical interference, and sometimes castration. In the last case I operated upon, some months ago, the patient was an elderly man whose hydrocele had been tapped a number of times with temporary relief. Following the last tapping his scrotum had rapidly swollen in the course of a few weeks to the size of the head of a child a year old. Upon incising the greatly thickened tunica vaginalis a quantity of fluid blood, fibrin, and clots were evacuated. The sac of the hydrocele was much thickened. Its inner surface was rough. There were numerous hemorrhages into its substance and just beneath its surface. The testis looked and felt normal. The entire tunica vaginalis was excised as far as the borders and epididymis. The surface of the testis was swabbed with pure carbolic acid, and then with alcohol. The wound was closed with sutures except for a small rubber-tissue drain at its lower angle. Recovery was, so far as I am aware, permanent. In the more advanced cases the testis may be found atrophied; this and other local conditions may render castration the best treatment.

TUMORS OF THE SPERMATIC CORD AND OF THE COVERINGS OF THE TESTIS

Lipoma.—The most frequent tumor of the spermatic cord is lipoma. It is developed in the fat which normally surrounds the veins of the cord. It may extend from the external abdominal ring to the testis. The fat is continuous through the canal with the subperitoneal fat. Such a tumor may be mistaken for an omental hernia or for varicocele. The symptoms produced are an increase in the size of the cord, uniform or lobulated, and a sense of weight and discomfort. If the tumor attains a considerable size, it may cause atrophy of the testis. The treatment is early extirpation.

Fibroma.—Fibroma of the cord, either circumscribed or diffuse, and fibroma of the coverings of the testis have both been observed as rare tumors.

Sarcoma.—Sarcoma of the tunica propria of the testis has been recorded. It has sometimes followed hemorrhagic periorchitis. Sarcomata of the cord occasionally occur. They are to be distinguished from benign tumors by their rapid growth, their nodular form, and their tendency to infiltrate surrounding structures.

VARICOCELE

A varicose condition of the veins of the spermatic cord (pampiniform plexus) is one of the most common of all surgical diseases. Its frequency

is variously estimated at from one to ten per cent of young male adults. It is a disease almost peculiar to young manhood. The condition is very rarely observed before puberty, and does not appear except in the symptomatic form during advanced life. Varicocele usually disappears spontaneously with the decline of sexual vigor. It occurs in nearly all cases upon the left side. In a small proportion only upon the right. In these both sides are usually affected. Among 100 cases, Bennett found varicocele 80 times upon the left side alone, 19 times upon both sides, and only once upon the right side alone. To account for the preponderance of left-sided varicocele numerous theories have been advanced. The left testis hangs lower than the right. The left spermatic vein is longer than the right. The left spermatic vein empties into the renal vein at right angles. The right spermatic vein empties into the vena cava at an acute angle, more nearly in the direction of the blood current. The blood pressure in the renal vein is greater than in the vena cava. Hence, for these several reasons, there is greater hydrostatic pressure in the veins of the left side. The pressure of a distended sigmoid flexure is supposed to operate to impede the circulation in the left spermatic vein.

Persons with relaxed and flabby tissues and those who have to stand much upon their feet are more apt to develop varicocele than others. Individuals with strongly developed cremaster muscles and a firm scrotum do not have varicocele. When varicocele exists the scrotum is relaxed, pendent, and smooth. There is undoubtedly a congenital predisposition to the disease. In a considerable proportion of cases varicocele is associated with an unhygienic sexual life. In its milder forms it is frequently cured by marriage. The congestion of the sexual apparatus commonly present among those young men whose minds are continuously occupied with sexual ideas, but who are unable to practice sexual intercourse in a hygienic manner, is supposed to favor the occurrence of varicocele in a large proportion of cases.

Lesion.—The lesions of varicocele are the same as those observed in varicose veins of the lower extremity. The veins are lengthened, tortuous, and dilated with lateral saccular projections. The walls are thickened, the adventitia and intima are hypertrophied; the muscular coat atrophied. The most marked changes occur in the veins near the testis, and involve also the veins of the testis itself. The dilatation extends up to, sometimes into, the inguinal canal. Thrombosis of some of the veins is not uncommon, and small phleboliths are occasionally observed.

The Development and Symptoms of the Disease.—As a rule the veins become varicose slowly and gradually, sometimes more rapidly after prolonged and excessive muscular effort. Frequently repeated sexual excitement without gratification may cause the symptoms of an incipient varicocele to become suddenly more marked. In many cases varicocele produces no symptom at all. In others the patients complain of a sensation of fullness, weight, and sometimes of dragging pain, referred to the testicle. Sharp, neuralgic pain of an intermittent character may also be felt in the organ, as well as a dragging pain

felt along the spermatic cord. The symptoms are made worse by the erect posture and disappear when the patient is lying down. Sexual excitement makes the symptoms worse. Coitus relieves them temporarily. Marked varicocele may be followed by partial atrophy of the testis. It never produces impotence.

Physical Signs and Diagnosis.—The diagnosis of varicocele is simple. The patients are young men. Upon examination the scrotum is found relaxed and pendent. The left testis feels smaller and softer than the right. In marked cases the long axis is horizontal, the epididymis lying above it. The mass of dilated veins may be visible in the lower part of the scrotum, and is always palpable as a bundle of tortuous soft cords running upward from the testis to the groin. The trite simile, "like a bundle of worms," is accurate. Upon pressure the veins are readily emptied, but instantly fill again when the pressure is removed. In mild cases the veins subside to normal dimensions when the patient lies down, but reappear at once when he stands erect. When the varicosities extend into the inguinal canal there is an impulse on coughing. Pressure upon the external ring prevents the descent of a hernia into the scrotum. It has no such effect upon a varicocele. On the contrary, such pressure, if moderate, causes further distention of the mass of veins. It must, of course, be borne in mind that a hernia and a varicocele may coexist. A lipoma of the cord has not the characteristic feeling of a bundle of soft cords, and is unchanged in its size by the recumbent posture and by elevation of the scrotum.

FIG. 240.—RECURRENT VARICOCELE.
(New York Hospital collection.)

Prognosis.—Marked cases of varicocele, untreated, produce in time atrophy of the testis. Such cases demand excision of the veins of the spermatic plexus and suture of the divided stumps, thus at once curing the varicose veins and elevating the testis. The subcutaneous ligation of the veins is not popular

among general surgeons. The less severe cases may be treated by cold baths, a suspensory bandage, and sexual hygiene.

Symptomatic Varicocele.—Under tumors of the kidney we have mentioned that marked varicosity of the veins of the spermatic cord is sometimes observed when tumors of the kidney press upon the renal vein. Such venous engorgement does not occur until the tumor has reached a large size, or has grown into the vein and occluded it, or has formed secondary tumors which press upon it. Such tumors are usually readily palpable through the abdominal wall. In the cases I have seen the varicosities enormously exceeded in size those observed in varicocele. The tumors were found to be malignant, and either inoperable or beyond the hope of permanent cure by operation.

DIAGNOSIS OF THE CONGENITAL ANOMALIES OF THE TESTIS

When a testis remains in the abdominal cavity its presence can only be inferred. A testis at the external abdominal ring or within the canal is readily recognized by palpation. In the latter case the process of peritoneum usually remains open; a congenital hernia probably coexists.

Ectopia Testis.—Ectopia testis, or the implantation of the testis in an abnormal situation, is to be recognized by the absence of the testis from the scrotum and the finding of a body, resembling a testis in form, size, and consistence, in the perineum, in the groin, or upon the pubes. It will be observed that an abnormally placed testis is more readily moved about and is softer than a normally placed organ. Testes which remain within the abdominal cavity are usually functionless. Those which remain in the inguinal canal, up to and after the time of puberty, are either atrophic or they may functionate for a few years and then become atrophic. Such testes are exposed to mechanical injury and to attacks of inflammation. They are probably more apt to become the seat of malignant disease than are normally placed testes. Inguinal testes should be operated upon and brought into the scrotum after the age of five years and before puberty. If they can be kept in the scrotum they will probably develop and functionate in a fairly normal manner. Observation tends to show that retained testes may become functionally active, and remain so for a few years, but that they soon undergo permanent atrophy. No cases are on record where individuals with double retained testes have preserved the procreative power during a long period of years. When operating for congenital hernia in the young, it is better to bring an inguinal testis down into the scrotum than to remove it. In a man over twenty-five years of age, such a testis is better removed than left.

INVERSION OF THE TESTIS AND TORSION OF THE CORD WITH STRANGULATION OF THE TESTIS

Anomalies in the descent of the testis are often associated with an increased mobility of the organ. Thus, when the descent of the testis is delayed,

the processus vaginalis may precede it into or beyond the inguinal canal. The testis descending later projects into a pouch of peritoneum of considerable size, in which it may come to hang with a lengthened mesorchium. Thus the conditions are favorable not only for the abnormal mobility commonly observed in inguinal testes, but also for rotation of the organ upon a horizontal or vertical axis. From the former the testis may come to lie with its long axis horizontal, or may be turned completely over, end for end. The rotation on a vertical axis is more important. The testis may be rotated through ninety degrees, so that the epididymis lies in front of it, the tunica vaginalis behind. Though extremely rare, the possibility of this condition should be borne in mind when about to tap a hydrocele or to introduce a needle into a tumor of the scrotum for any reason. By careful palpation the relative positions of the testis and epididymis can usually be identified.

A rare but possible result of abnormal mobility of the testis is *sudden rotation around a vertical axis, with torsion of the cord and strangulation of its vessels,* followed by *gangrene* or *sloughing* of the testis in the majority of instances, or, in the minority, by *atrophy.* The accident is a rare one. I have been unable to find a record of any case of the kind treated in the New York Hospital. Scudder, in 1901, was able to collect only thirty-two published cases, including one of his own.[1]

In about half the cases an abnormality in the descent of the testis existed. It is probable that twisting of an entirely normal testis rarely, if ever, occurs. The accident has happened chiefly to young men, though infancy and old age were not exempt. In sixteen per cent of the collected cases there was a hernia present on the same side as the twisted testicle. Gangrene of the testicle occurred in eighty-eight per cent. Though all the recorded cases recovered, the testis was destroyed by gangrene sloughing or subsequent atrophy in all but two, the later history of these being unknown.

The accident has followed a blow or fall upon the scrotum or groin, a blow upon a hernia, or has occurred after severe muscular strain. In some cases the torsion has taken place spontaneously, without assignable cause.

Symptoms.—The symptoms are almost identical with those of strangulated hernia, for which the condition has been mistaken in a large proportion of cases. The patient is suddenly seized with a violent pain in the testis and along the cord, accompanied by faintness, and often by nausea and vomiting. Constipation may or may not be absolute. A tumor, exquisitely tender and very painful, appears in the inguinal canal or scrotum. The testis swells rapidly. If not operated upon at once, the overlying scrotum becomes swollen, red, and edematous. In a very few hours all the vessels are filled with thrombi, and the vitality of the testis is hopelessly lost. In a few cases the condition is not so acute. The symptoms have come on gradually, and lasted several days before strangulation was complete. In other cases successive attacks have

[1] *Annals of Surgery,* August, 1901, p. 234.

occurred, and one patient learned to recognize the condition and untwist his own testis. When the condition is not associated with hernia and the testis lies in the scrotum, the absence of the signs of hernia and palpation of the scrotal tumor may enable the surgeon to make a correct diagnosis. If, however, as has frequently been the case, a hernia has previously existed, or if the testis is in the inguinal canal, a differential diagnosis from strangulated hernia can scarcely be made. The indications in either case are immediate operation. If the patient is seen within an hour or two of the onset of the symptoms and the testis lies in the scrotum, it may be successfully untwisted, as in the cases of Nash and Van der Poel. If several hours have elapsed, thrombosis will have occurred, and castration is the only proper method of procedure, otherwise gangrene of the testis will follow. If the surgeon succeeds in opening the scrotum while the testis is apparently still capable of surviving, the organ should be untwisted and carefully anchored to the scrotum by sutures. Even in such cases the testis is very apt to undergo subsequent atrophy.

Upon operation the tunica vaginalis has usually been found distended with bloody fluid, the testis purple, blue, or black, and gangrenous. The cord has been found twisted in either direction. One or more complete turns have usually been present.

INJURIES OF THE TESTIS AND EPIDIDYMIS

Contusions of the Testis.—Subcutaneous injuries of the testis are less frequent than might be inferred from its exposed position, since the organ readily slips out of the way if in danger. Contusions of the testis occur from blows, kicks, falls, and the like. Falls a-straddle of rails or against the pommel of a saddle are common causes. In a few cases a baseball, batted or thrown, has injured the testis. Associated injury of the epididymis is frequent. The lesions vary in severity from slight ecchymosis into the substance of the organ to rupture of the tunica albuginea or actual pulpification of the testicular substance. An effusion of blood into the tunica vaginalis (hematocele) is a frequent complication. Severe contusions of the testis are apt to be followed by a sharp inflammatory reaction. Epididymitis and orchitis, even sloughing or atrophy, of the testis may occur. In the cases accompanied by marked laceration of the testis or epididymis a permanent nodular scar is left at the site of the injury. Such may cause partial or total impairment of the function of the testis. A method of making eunuchs for domestic use, said to be practiced in some of the countries of the Orient and by a peculiar Christian sect in Russia known as the Skopzi, is by crushing and pulpifying the testes with the fingers. The unfortunate victim is seated over a steaming kettle of water, and the testes are repeatedly crushed between the finger and thumb until disintegrated. The operation is said to be followed sometimes by sloughing. The same procedure is sometimes used upon dogs, cats, and goats.

Symptoms of Contusion of the Testis.—Every man is aware of the sickening pain and faintness which follow slight blows upon the testis. Severe contusions are followed by intense pain, by prostration, nausea and vomiting, and marked muscular weakness, sometimes by syncope; in other words, by marked **shock.** In a few recorded cases such shock has been fatal. The presence of these symptoms serves at once to distinguish between contusion of the testis and mere contusion of the scrotum.

Physical Signs of Contusion of the Testis.—The testis is swollen and exquisitely tender. Immediate effusion into the tunica vaginalis points to laceration of the tunica propria testis, or epididymis. Ecchymosis may appear at once from the associated contusion of the scrotum. Its absence at first and appearance after several days confirms the diagnosis of injury to the testis. Accurate palpation of testis and epididymis is at first difficult or impossible, on account of extreme tenderness and the swollen condition of the scrotum. Later on, when the scrotum is reduced in size, localized nodules may be felt in the testis or epididymis. These locate the site of the injury. The tail of the epididymis appears to be the most frequent site of such lesions. Under rest, elevation and cold, the pain usually subsides rapidly. Severe injuries may be followed by sloughing or atrophy of the testis.

Dislocation of the Testis.—The testis may be displaced from its normal position by direct violence or by muscular action. By the former into the perineum, the groin, upon the pubes, or into the inguinal canal; by the latter into the inguinal canal. A case is recorded where the testis was suddenly drawn into the inguinal canal during masturbation. It remained there, and was later removed in an atrophic state.

When the testicle is dislocated by direct violence the diagnosis is to be made from the history of the injury, the absence of the testis from the scrotum, the pain, and the presence of a mass having the characters of the testis in an abnormal situation. The testis should be replaced by manipulation, if possible, or by a cutting operation, if needs must. If let alone it will probably atrophy.

Open Wounds of the Testis.—Open wounds of the testis offer no difficulty in diagnosis. If the hole in the tunica propria is of considerable size the testicular substance protrudes through the opening. If the wound is fresh, further prolapse should be prevented by suture of the tunica propria. The protruding glandular substance may be snipped off, if necessary. *In no case should the testicular substance be pulled upon.*

Punctured Wounds of the Testis.—Punctured wounds occur most often from the careless tapping of a hydrocele. They are rarely of any moment.

Gunshot Wounds of the Testis.—Gunshot wounds of the testis are usually associated with extensive laceration and pulpification of the organ. Castration may be required. Any accidental wound of the testis may be followed by infection and suppuration or gangrene.

The Results of Injuries to the Cord.—Section of the vas deferens does not cause atrophy of the testis.

Simultaneous ligation of the pampiniform plexus and of the veins of the vas deferens is usually followed by atrophy of the testis.

Ligation of the spermatic artery and of the pampiniform plexus does not, as a rule, seriously affect the nutrition of the testis. Ligation of the entire spermatic cord is sometimes followed by simple atrophy of the testis, sometimes by gangrene.

DISEASES OF THE TESTIS AND EPIDIDYMIS

Inflammation of the epididymis (epididymitis) and of the testis (orchitis) may occur separately or together (epididymo-orchitis).

The inflammation usually begins in one structure. It may be confined to that or extend to the other. Epididymitis is much more frequent than orchitis.

Causes of Epididymitis and of Orchitis.—(1) Direct trauma; trauma to the posterior urethra combined with infection, pyogenic or gonorrheal. (2) Extension of an infectious inflammation of the posterior urethra by continuity of structure through the ejaculatory duct and vas deferens to the epididymis and testis, or extension from the seminal vesicle by the same route. (3) Metastatic and hematogenous infections.

It will be convenient to consider the inflammations of the epididymis and testis in part separately, since though the two are often combined, the signs and symptoms due to inflammation of one usually predominate in the clinical picture.

1. Direct Trauma.—Direct trauma as a cause of epididymitis has been mentioned under Injuries of the Testis and Epididymis.

Epididymitis as the result of muscular effort, notably of lifting, has been described by a number of authors. The mode of production is supposed to be that the testis is suddenly drawn upward against the pillars of the ring, and thus injured. Such a causation would appear to me to be doubtful.

Traumatisms to the posterior urethra from the passage of instruments and from operations upon the urethra, prostate, and bladder are frequent causes of epididymitis. The injuries are always combined with infection: sometimes with gonococci, sometimes with ordinary pyogenic microbes. Such may be already present in the urethra, or may be introduced at the time of instrumentation. The passage of calculi may act in a similar manner.

2. Extension of an Infectious Inflammation of the Posterior Urethra.—Much the most frequent cause of epididymitis is the extension of a gonorrheal infection from the posterior urethra.

Acute gonorrhea is followed by epididymitis in a considerable proportion of cases, variously estimated at from five to twenty-five per cent. How great an influence local treatment has in its production it is hard to say. No one denies that unwise instrumentation and the improper use of injections may cause infection of the posterior urethra, and yet posterior urethritis and epididymitis are observed so often in cases where no local treatment has been used

and where the patients have led the most careful of lives that we are forced to doubt the causative relation of local treatment in most of the cases. *A fortiori,* since, in the opinion of careful observers of large experience, the surest way to prevent the complications of gonorrhea and to cure the disease in the shortest time is to begin local treatment early, and to carry it out energetically.

To carry out the local treatment with the best prospect of success the surgeon should make the injections himself, two or three times daily. The patient should keep to his room. Alkalies, a simple diet, and free evacuation of the bowels sum up the treatment. Argyrol solution is the best injection, in a strength of ten per cent, until the gonococci have disappeared and the discharge is reduced to a minimum. Permanganate irrigations and nitrate of silver complete the cure. Under favorable conditions the patient is well in from one to two months.

It is certain that violent muscular effort, notably horseback and bicycle riding, favor the occurrence of epididymitis. These forms of exercise probably act mechanically to permit the entrance of the contagious discharge into the prostatic urethra. Sexual excitement and the use of alcohol during acute gonorrhea predispose to epididymitis.

Epididymitis usually occurs during the second or third week of gonorrhea—seldom earlier, often later. Usually but one side is involved, though the other is often invaded later. In a very few cases both sides may be affected simultaneously. One attack predisposes to others. A man who has had epididymitis once will probably have it again with each succeeding infection.

Symptoms.—In the acute cases the onset is sudden. Certain so-called prodromal symptoms are usually present. They are pain in the sacrum and lumbar region of the affected side; pain along the course of the cord and often marked pain and tenderness over the internal abdominal ring, or a little above it. When upon the right side, this sign has been mistaken for appendicitis. These symptoms indicate the progress of the inflammation along the vas deferens. Chilly sensations, together with slight fever and prostration, may usher in the complication. When the epididymis begins to swell the urethral discharge ceases or diminishes, to return again when the inflammation of the epididymis subsides. The swelling of the epididymis comes on suddenly. The tail (globus minor) is first affected, and in some cases the inflammation may be confined to that part. Within three or four days the swelling reaches its height. The scrotum, as large as a closed fist, is swollen, red, and edematous. The epididymis may swell to the size of a goose egg. It overrides the testis above and below, and overlaps it laterally as a firm, rather helmet-shaped mass of inflammatory infiltration, very hard and very tender. The testis can be made out readily on the anterior face of the tumor unless the tunica vaginalis contains fluid. The testis, as a rule, feels quite normal.

Pain.—The pain of epididymitis is severe, and of a sickening, weakening quality; much worse when the patient stands, relieved when he lies down, with the scrotum supported. His motions are slow and cautious. He walks care-

fully, and protects his scrotum or supports it with his hand when circumstances permit. In some cases there is an acute periorchitis, with effusion into the tunica vaginalis and exquisite pain from tension. (See Acute Periorchitis.) The pain remains severe for several days, but subsides, together with such constitutional symptoms as may be present, before the swelling has perceptibly diminished. In ten days or two weeks the acute symptoms have usually disappeared. Tenderness remains for some days longer. The swelling grows rapidly less during the early days of convalescence, but a considerable mass remains, usually in the tail of the epididymis, which diminishes in size very slowly. This remains in most cases as a telltale nodule throughout the patient's life, though it ceases to give symptoms. The testis may be temporarily or permanently disabled. (See Pathological Changes in the Semen.)

Funiculitis may accompany epididymitis. The cord becomes swollen, infiltrated, and painful, and may be partly strangulated at the abdominal ring. The pain and other symptoms are thereby rendered much worse.

Suppuration is a rare accident in the course of epididymitis. It is to be recognized by increased pain and tenderness, and by other local symptoms of abscess. A localized point of tenderness, softening, adhesion to the scrotum, and fluctuation become evident. The general symptoms of sepsis are well marked.

It is usually easy to distinguish epididymitis from orchitis. In the former the normal testis can be made out by palpation. The pain of orchitis is terribly severe, and is not relieved by change of position. The pain of epididymitis is relieved by lying down and support of the scrotum. Primary orchitis as the result of gonorrhea is very rare.

Subacute, Chronic, and Relapsing Epididymitis—Recurrent Epididymitis.—In some cases the signs and symptoms of epididymitis are subacute from the first. Marked pain and swelling are wanting. A tender nodule of moderate size forms in the tail, less often in the head of the organ, or in both. The patient is not confined to his bed, but gets about with more or less discomfort, wearing a suspensory bandage. The function of the testis may be destroyed, nevertheless.

Chronic and relapsing epididymitis usually follow the acute forms and merge into the recurrent type of the disease. In the last the patients suffer from recurrent attacks of epididymitis throughout a period of years. Chronic posterior urethritis, stricture of the urethra, prostatitis, and seminal vesiculitis are the commonly associated lesions. These cases may be cured of the recurring attacks of epididymitis by cutting the vas deferens.

Epididymitis the result of instrumentation may be due to the gonococcus or to ordinary pus microbes. In some cases the inflammation is subacute, ending in resolution; in others, a smaller number, suppuration occurs. Stricture of the urethra, prostatic hypertrophy with an insufficient bladder and cystitis, and chronic posterior urethritis are the commonly associated lesions.

Tuberculous epididymitis is to be distinguished from the acute form of urethral origin by its gradual onset, absence of pain, tenderness, and other signs of acute inflammation, its slow and chronic course, and usually by the presence of tuberculous lesions of the prostate or in distant parts of the body. There is nearly always an associated periorchitis, with moderate effusion into the tunica vaginalis. (See Tuberculosis of the Testis and Epididymis.)

Orchitis.—Orchitis the result of direct trauma is described under Injuries of the Testis and Epididymis.

Orchitis of Urethral Origin.—The testis itself is very rarely affected in the course of acute gonorrhea, the infection being localized, as a rule, in the epididymis. In chronic inflammations of the posterior urethra, the prostate, the bladder, and as the result of instrumentation in these conditions, the testis may become inflamed alone or together with the epididymis. In these cases, though the gonococcus may be present in the urethra, the lesion of the testis is usually caused by other pyogenic bacteria. The inflammation may be subacute, ending in resolution. In other cases it is acute; and, though no abscess forms recognizable by ordinary methods of examination, a greater or less portion of the glandular substance is replaced by scar tissue. In some cases the process ends in suppuration or in necrosis of the testis. If an abscess forms in the testis, it may perforate the scrotum and be incised or burst spontaneously. A persistent sinus often remains.

Metastatic and Hematogenous Inflammations of the Testis.—Pyemia, septicemia, the acute exanthemata—notably variola, typhoid fever, pneumonia—and some other general diseases may be followed by orchitis, often of a suppurating type. Mumps, influenza, and polyarticular rheumatism may be accompanied by orchitis, very rarely followed by suppuration, quite commonly followed by atrophy of the testis.

Mumps is attended by orchitis in a fairly large proportion of cases. It is a common complication at or about the age of puberty and during early manhood. It is rare among children. The lesion of the testis may accompany, follow, or precede the inflammation of the parotid gland. One or both testes may be involved. Suppuration is very rare. Total atrophy of the testis is very common. In some epidemics atrophy has occurred in nearly one half of the cases. Orchitis during typhoid fever may be due to pyogenic microbes or to the Bacillus typhosus itself. Suppuration is common. Orchitis as a complication of the exanthemata is probably due to pyogenic microbes. Localization of a septic focus in the testis is occasionally observed in the course of septicemia and pyemia.

Symptoms of Orchitis.—The onset is usually sudden. If the process is of a suppurative character the general symptoms of sepsis will be more or less marked—i. e., fever, prostration, leucocytosis, etc. The testis becomes exquisitely tender and painful. It may swell in the course of two or three days to the size of a goose egg. The tension within the tense tunica albuginea causes

excruciating pain, not relieved by the recumbent position nor by elevation of the testis.

Physical Signs.—The scrotum is swollen, the skin smooth, the subcutaneous veins dilated; but unless the infection has already penetrated the tunica albuginea, the skin is neither red nor edematous. Upon palpation the testis is found enlarged. The surface is smooth, the normal shape of the organ is preserved. It is exquisitely tender, and feels firmer than normal. It is sometimes possible to palpate the epididymis as a ridge upon the back of the testis. If the tunica vaginalis contains much fluid, the recognition of the testis may be more difficult until the fluid is removed. When suppuration occurs the testis will become adherent to the scrotum, and the latter will be red and edematous. Fluctuation may be recognized. In certain cases total necrosis of the testis occurs quite suddenly without the formation of an abscess. In these the severe pain may suddenly cease after several days, often an indication that the testis is necrotic. In those cases which are permitted to rupture externally or incised for the evacuation of pus, a persistent sinus leading to an abscess cavity in the testis may remain behind. Some of these cases can only be cured by castration. The granulations sprouting from the interior of such a testis and the extruded glandular substance are sometimes spoken of as *benign fungus of the testis.*

A *chronic orchitis* may follow an acute attack, or in rare instances begin as such. Two forms have been described: one a diffuse type of interstitial inflammation, with marked increase in the size of the testis, the other characterized by the formation of minute circumscribed abscesses in the substance of the organ surrounded by masses of cicatricial tissue. Both these conditions are extremely rare.

Tuberculosis of the Testis and Epididymis.—Tuberculosis of the testis and epididymis occurs in two forms: (1) As a part of the lesion of acute general miliary tuberculosis; (2) as a localized lesion. The first form is of no interest from a surgical point of view. In the second form the epididymis is nearly always first affected, the lesion of the testis being due to direct extension. Much controversy has arisen in the past as to the mode of infection in cases of tuberculosis of the epididymis. The following facts have been determined by observation: Tuberculosis of the epididymis is rarely, if ever, a primary focus of tuberculosis in the body. It is often seen together with tuberculosis of the lungs, the joints, and the bronchial lymph nodes, and still more often is it associated with tuberculosis of other portions of the genito-urinary tract, the kidney, the prostate, the seminal vesicles, the bladder. The question in dispute has been whether the tuberculous lesion is primary in the epididymis and thence invades the prostate, or whether the infection proceeds in the other direction—namely, from the prostate to the epididymis. My own opinion is, that both methods of infection occur, but that the epididymis is first infected by a tuberculous embolus in the larger proportion of cases. I believe in an ascending infection from the bladder to the kidney, and also I believe that

tuberculosis of the kidney may produce secondary tuberculosis of any part of the lower genito-urinary tract.

While, as stated, the epididymis is usually first infected, the testis later, still, cases are observed in which the testis is undoubtedly infected first.

The Lesion.—The lesions of tuberculosis of the testis and epididymis consist in the formation of tuberculous nodules in the substance of the epididymis which undergo the regular changes—caseation, softening, the formation of cavities filled with creamy and cheesy material and lined by a wall of tuberculous granulation tissue. The overlying structures are finally invaded, the skin perforated, discharge of tuberculous material follows, and a tuberculous sinus remains behind, its external orifice being surrounded by a collar of typical tuberculous granulation tissue. The invasion of the testis follows the tubules into the substance of the testis and submiliary and larger tubercles develop in the substance of the organ. These coalesce, soften, and form tuberculous cavities of greater or less size, usually ending in total destruction of the organ. One of the commonest associated lesions of beginning tuberculosis of the epididymis is a periorchitis with a sero-fibrinous exudate in the tunica vaginalis, usually moderate in quantity. In a large proportion of cases tuberculosis of the epididymis and testis is associated with tuberculosis of the prostate. In a certain proportion of cases tuberculous infection of the epididymis follows injury, and gonorrheal epididymitis has sometimes preceded the manifestations of tuberculosis. The disease is most often seen after puberty and during early manhood, and yet it may occur at any age. The invasion of the epididymis is evidenced by the formation of one or more hard, painless, insensitive nodules in the head or tail of the epididymis, or both. The nodules increase in size rather rapidly, so that at the end of two or three months the head or tail of the epididymis may be as large as the last joint of one's thumb. Sooner or later softening occurs, with perforation of the skin, the discharge of tuberculous material, and the formation of a sinus surrounded by fungating granulations. The disease is extremely chronic.

Fig. 241.—Double Tuberculous Epididymitis with a Small Amount of Fluid in the Tunica Vaginalis of Either Side. (New York Hospital, service of Dr. Frank Hartley.)

I have seen patients in this condition going about without operative treatment for many years. Such patients may remain in fairly good health. In other cases they will suffer from loss of flesh and strength, and become anemic. In many cases there will be in addition the signs and symptoms of tuberculosis of the lungs, the bones, the joints, but more especially of other portions of the genito-urinary apparatus—the kidney, the prostate, etc. I do not know that I have ever seen a case of tubercular epididymitis whose urine was entirely free from catarrhal ingredients. When the testis is invaded it becomes swollen and lumpy, losing its smooth and evenly elastic contour; later on, after extensive softening has occurred, the tunica propria may be converted into a sac containing nothing but broken-down tuberculous material. Earlier in the disease the entire substance may be studded with tubercles the size of a No. 8 shot, or there may be larger circumscribed areas of tuberculous infiltration or softening while the remainder of the testis appears to be nearly normal. In this latter group of cases it has seemed to me probable that the testis was originally infected before the epididymis, since the lesion of the latter was less far advanced. The opposite finding is, however, the rule. In some cases the testis is notably increased in size; in others it is scarcely swollen. In a large proportion of cases the invasion of one testis is followed after months or years by infection of the other. This has been used by many surgeons as an argument in favor of conservative operations upon the tuberculous epididymis. It appears to me to be rather an argument in favor of castration in cases of tubercular epididymitis, especially when the remainder of the genito-urinary tract appears to be fairly healthy, since by this means we give the patient the best chance to preserve his remaining testis intact. Advanced cases of tuberculosis of the testis and epididymis are commonly associated with tuberculosis of the vas deferens. The vas is thickened, often nodular. As much of it as possible should be removed with the testis. In a small proportion of cases I have seen a tuberculous epididymitis run a very acute course resembling that of gonorrheal epididymitis. In some of these the acute inflammation subsided and became chronic; in one it was followed by acute general miliary tuberculosis and death in five weeks from the beginning of the swelling in the epididymis. In another it was followed by a rapidly fatal, generalized, tuberculous peritonitis. In a few cases, after the formation of sinuses, the disease may go on under favorable surroundings to what might be called an apparent cure. The sinuses close, leaving hard, cicatricial nodules in the epididymis, which may remain quiescent for years. Such cases are exceptional. In a few cases pyogenic infection occurs, with suppuration and destruction of the testicle. In many cases death occurs from tuberculosis of the lungs or from tuberculosis of other portions of the genito-urinary tract.

Prognosis.—The prognosis depends chiefly upon whether it is possible to remove all the foci of tuberculosis and to put the patient under the most favorable hygienic conditions.

Differential Diagnosis.—The differential diagnosis is usually not difficult. The process is with rare exceptions far more chronic than gonorrheal epididymitis. The epididymis is nearly always involved before the testis, the contrary being true in syphilis of the testis. The painless onset, the chronic course, the formation of sinuses, and the frequent presence of other tuberculous lesions are all important data. In the rare cases where the testis is first invaded the diagnosis may be more difficult; in these we may have to depend upon prolonged observation, a history of syphilis or of tuberculosis, the administration of iodid of potash and mercury. In a few cases no certain diagnosis can be made except by an exploratory incision.

Syphilis of the Testis.—Syphilis of the testis is a relatively frequent lesion. The disease involves *the testis first*, as a rule, to which exceptions are rare. This localization serves in nearly all cases as a distinguishing mark from tuberculosis. The epididymis is, however, quite commonly invaded, together with the testis. Primary syphilitic sclerosis of the epididymis may rarely occur. Syphilis of the testis is usually one of the later lesions of the disease. During the first year following infection it may occur in the so-called precocious cases of syphilis. In the records of Keyes more than half the cases were observed during the first four years. Postponement for many years is not uncommon. Though but one testis is usually affected, bilateral invasion is by no means rare. Hereditary syphilis may affect the testis during childhood.

Lesions.—Two forms of syphilitic inflammation of the testis occur, though they often exist in combination.

1. *The Sclerosing Form.*—An interstitial inflammation of the tunica albuginea and of the fibrous septa of the testis. This is a diffuse lesion characterized by an interstitial inflammation of the fibrous stroma of the testis. The fibrous tissue is increased in amount, and causes atrophy by pressure of the secreting substance. The testis is at first moderately increased in size. Cicatricial contraction of the fibrous tissue follows. The testis becomes smaller than normal and very hard. Total atrophy of the parenchyma is common. With this lesion there may be combined the formation of larger or smaller gummatous nodules. The process rarely if ever ends in the formation of gummatous ulcers. The course is exceedingly chronic and usually quite painless. An adhesive periorchitis often coexists. The tunica vaginalis may contain a small amount of serous fluid.

2. *Gummatous Orchitis, Nodular Syphilitic Testis.*—The process is more acute than in the sclerotic form. Larger or smaller gummata are formed in the testis, hand in hand with a more or less diffuse surrounding sclerosis. The testis is increased in size and may attain the dimensions of a man's fist. The tumor formed is more or less irregular and nodular in shape, as hard as wood, painless, and insensitive. The tubules of the testis are compressed. The secreting substance undergoes atrophy. Some portion of normal structure is usually preserved. The testis still produces spermatozoa, though in diminished numbers. The epididymis may also be the seat of a sclerotic inflamma-

tion. In some cases the gummatous material undergoes absorption, leaving corresponding pits in the substance of the testis surrounded by dense scar tissue. In other and more acute cases softening occurs. The overlying structures are perforated. The skin becomes purple, breaks down, leaving a crateriform cavity, with irregular, undermined edges and a characteristic sloughy base. From the raw surface unhealthy, fungating granulations may sprout forth, projecting above the level of the skin, forming the so-called syphilitic fungus of the testis. In these cases the tunica vaginalis usually contains a moderate quantity of serous fluid. In these cases the epididymis is often the

FIG. 242.—GUMMA OF THE TESTIS. (New York Hospital, service of Dr. F. H. Markoe.)

seat of a diffuse interstitial inflammation, which may involve the entire organ, but is more commonly confined to the globus major. The lesion of the epididymis is distinctly a diffuse sclerotic process, the formation of gummata of the nodular type in the epididymis being extremely rare. In many instances the epididymis forms a hard, painless, insensitive tumor which overlaps the upper pole of the testis, having a sharply marked anterior edge beneath which can be felt a distinct sulcus. The enlarged epididymis has been likened in shape to the front of a helmet or to a clam shell capping the testis.

THE SYMPTOMS, COURSE OF THE DISEASE, AND DIAGNOSIS.—Syphilis of the testis is characterized, as a general rule, to which there are some exceptions, to be mentioned later, by its insidious onset, its exceedingly chronic course, by the stony hardness of the enlarged testicle, by absence of pain and tenderness, by the fact that the spermatic cord remains healthy and that the condition of the testis improves under active antisyphilitic treatment. In a few exceptional cases of gumma of the testis the onset may be fairly acute. The testis and epididymis may rather rapidly increase in size, and such swelling may be

attended by a certain amount of pain and tenderness. These symptoms, however, soon subside, after which the condition runs an exceedingly chronic course. In many cases the patients are not aware of any trouble with the testis until a dragging sensation on the cord calls attention to a diffuse swelling and induration of the organ. Usually the general health does not suffer, and the patients are only incommoded by the size of the tumor, sometimes increased by the presence of a hydrocele. In the sclerotic form, if untreated, the testis after months or years undergoes atrophy, and remains as a mere nodule of scar tissue in the scrotum. If both testicles are involved in this process the patients become sterile, and sometimes wholly or partly impotent. In the group of cases attended by the formation of large gummata the testis is usually greatly enlarged; the surface of the tumor may be of uniform consistence or hard nodules may alternate with softer areas. When the gummata break down the appearances of the syphilitic ulcer are perfectly characteristic. The fungating granulations which subsequently sprout from the raw surface are unwholesome, yellowish-red in color, sometimes harder, sometimes softer, and always quite painless and insensitive. While in the majority of instances the diagnosis of syphilis of the testis is easy, cases do occur in which such is not the case. The following data may be borne in mind: Syphilis affects first the testis. Tuberculosis first affects the epididymis. The cord remains free in syphilis; so, also, does the epididymis in many cases. If hydrocele is present, the fluid should be drawn off so that the testis may be palpated. The physical characters of the testis have already been described. When the epididymis is also involved a differentiation from tuberculosis may be necessary. A history of syphilis and the presence of syphilitic lesions or scars elsewhere on the body may aid in the diagnosis, as may also a tubercular habitus and the recognition of other tuberculous lesions, notably of the lungs, kidney, or prostate. Tuberculosis of the epididymis often forms perforations of the scrotum and tuberculous sinuses quite early in the disease. Gummata of the testis may exist indefinitely without breaking down, and the appearance of tertiary syphilitic ulcerations is usually absolutely characteristic to the trained eye. Syphilis is often confounded with malignant tumors of the testis. The progress of the latter is usually more rapid than that of the former. If the slightest doubt exists the patient should receive the benefit of it, and be placed under the most active antisyphilitic treatment, preferably by the subcutaneous injection of salicylate of mercury and the use of very large doses of iodid of potassium internally. If the testicle is syphilitic, some improvement ought to be noticed in less than a month.

It should be borne in mind that syphilis of the testicle may exist for years without totally destroying the function of the organ, and that as the result of treatment the remaining glandular substance may be preserved.

Tumors of the Testis.—The testis is one of the rarer sites of tumor formation, although almost every variety of new growth has been described as originating in this organ. Confusion has existed in the classification of tumors of

the testis, since most of them belong to the group of embryomata, or so-called "mixed tumors," or teratomata—i. e., tumors containing structures derived from all three blastodermic layers. These tumors are composed of a great variety of tissues and of cells, variously arranged and in varying proportions, in individual growths and in different parts of the same growth. They closely resemble the mixed tumors observed in the parotid gland and in the kidneys of infants. Thus, in different parts of the same tumor we may find areas of fibrous tissue, mucous tissue, bone, striped and unstriped muscle fibers, cartilage, glandular tissue, as well as cystic formations, and of tissue resembling the various forms of sarcoma and carcinoma. In some specimens one or other type of tissue may predominate; thus we may find a tumor composed largely of cartilage containing numerous cystic cavities. In another growth we may find one or other types of sarcomatous tissue in large amount, with numerous striped muscle fibers, and so on throughout many possible combinations. These tumors have several characters in common, no matter what tissue may predominate. They are quite commonly observed during childhood or early adult life, and at such times may be so small as scarcely to attract attention. They often exist for years without notable increase in size, and then, sometimes as the result of injury, sometimes without assignable cause, grow rapidly, infect the retroperitoneal lymph nodes, produce distant metastases in the lungs, the brain, and other organs, thus exhibiting all the characters of extreme malignancy. The primary growth may appear to be a chondroma, a sarcoma, or carcinoma. In any case, however, the tumor rapidly destroys life. This tendency to recurrence in different organs, perhaps years after removal, is exceedingly marked. Death may occur in this way within a year. The prognosis, therefore, is exceedingly bad. The histogenesis of these embryomata of the testis is even now not absolutely clear. It is certain that nearly all of them originate in the epididymis or the hilum of the testis. The tubules of the paradidymis (mesonephros, Wolffian body) seems to be their most probable origin. Their malignancy is undoubted. In one case which came under my observation the patient died twelve years after the removal of his testis, from a recurrence in the lung. The physical characters of these tumors will, of course, vary with the nature of the tissue composing them, so that no special diagnostic data can be based upon the physical signs observed on palpation, etc. These facts make it exceedingly difficult to tell the exact character of any tumor of the testis before it is removed. It has been customary with many writers to designate tumors of the testis by the name of the tissue or tissues predominating in the growth, as, for example, fibroma, myxoma, adenoma, cystadenoma, chondroma, sarcoma, carcinoma, etc., or some combination of these titles. The probabilities are that very few tumors of the testis are composed exclusively of one type of tissue. Most of them are mixed tumors.

Benign Tumors.—Various forms of benign growths have been observed in the testis. They are surgical rarities. Fibroma of the tunica vaginalis and of the tunica albuginea has been described, as well as lipoma of the latter. In

the testis itself there have been described fibroma, osteoma, myoma, myxoma, chondroma, cystoma, cystadenoma, etc. It is probable that many of these were examples of mixed tumors in which, on account of the preponderance of one or other type of tissue, the character of the growth was not recognized.

Dermoid Cysts or Simple Embryomata.—Certain benign cystic tumors of the testis occur. They are the dermoid cysts or simple embryomata. They occur within the tunica vaginalis, are connected with the testis, but apparently do not originate in its glandular substance. Some twenty-odd cases only of this kind have been reported. But little additional knowledge of their origin has been gained since they were studied by Verneuil more than fifty years ago. He regarded them as fragmentary parasitic fetuses. They are classified by Wilms among the simple "embryomata" as distinguished from the teratomata or mixed tumors of the testis—i. e., those derived from all three blastodermic layers. Their content does not differ from that of other dermoids. They are lined with skin, and contain hair, sometimes teeth, oily material, etc. In a few cases ganglionated nerve cells have been observed in the wall of the cyst. In most of the recorded cases the growth has been noticed during infancy, and a considerable proportion have been removed at an early period of life. In some cases enucleation has been possible, with preservation of the testis. Their growth has been slow. They have seldom attained a large size. Annoying symptoms have been absent until puberty. At this time some of them have become inflamed and infected from injury, and have produced abscesses and left behind sinuses. The probable diagnosis might be made from the history of the presence of the tumor since infancy, from its ovoid shape, from the putty-like consistence of its contents, its opacity to light, together with the absence of pain and tenderness if the overlying tissues were not inflamed. Aspiration might remove oily material. A certain diagnosis can only be made by operation.

Benign Cystic Degeneration of the Testis.—Benign cystic degeneration of the testis has been described by Curling and other authors. Clinically, it cannot be differentiated from malignant disease. The condition may exist alone or in combination with adenoma. Such tumors have been observed both in children and adults. They grow rather rapidly and may attain the size of a baseball, or larger. They form ovoid or spherical tumors of smooth surface and tense elastic consistence. If solid adenomatous tissue predominates, they will be firm tumors. Upon aspiration they furnish a mucoid, sticky, cloudy fluid containing no spermatozoa. Since the malignant cystic teratomata may exhibit all these characters, no differential diagnosis is possible without operation.

Sarcoma of the Testis.—Pure sarcoma of the testis is rare. Though it may be observed at any period of life, it is more common between the ages of twenty and fifty, 71 per cent of 114 cases collected by Kober. There was a history of injury in 43 per cent. Round-celled sarcoma was the most frequent form. Spindle-celled, mixed-celled, alveolar, and cystic types were also observed. Melanosarcoma, both primary and secondary, has occasionally been reported. The nodular type, surrounded by a sort of capsule, is the most fre-

quent, the infiltrating form being less common. The tumor may originate in the testis or epididymis. As it grows, the testis and epididymis are flattened out upon the surface of the tumor into a thin layer. For a time the nodule produces no symptoms, and may remain small for a long period and suddenly take on a very rapid growth, though it rarely forms a tumor larger than the adult fist. Sooner or later they perforate the tunica albuginea, invade the scrotum, ulcerate, and form a fungating mass of vascular sarcomatous tissue—the so-called "malignant fungus" or "fungus hematodes" of the older writers. They may also grow upward, involving the cord. When the tunica albuginea is perforated, hemorrhage often occurs into the tunica vaginalis, creating an hematocele, resulting in a sudden increase in the size of the scrotum. According to the character of the tissues composing the tumor, it remains hard or becomes soft or exhibits areas of fluctuation. Here, as elsewhere, the sarcomata exhibit in their later stages a tendency to various forms of degeneration, mucous, cystic, etc.; hematomata and areas of hemorrhagic infiltration are common. In the formation of metastases they do not differ from the mixed tumors. The lumbar glands are first affected and then those lying in front of the aorta as far as the diaphragm. These secondary growths may attain a large size and cause serious symptoms from pressure, abdominal pain, edema of the extremities, ascites.

FIG. 243.—SARCOMA OF THE RIGHT TESTIS. (Author's case.)

Prognosis.—The prognosis of sarcoma of the testis is exceedingly bad. It will depend to some extent upon the type of the original growth and upon the time of removal. Life is destroyed in the vast majority of cases; though apparent cure, if the tumor is removed early, may last for a number of years. The sarcomata of the testis, like the mixed tumors, are disseminated through the lymph channels rather than through the blood.

Tuberculous epididymitis is to be distinguished from the acute form of urethral origin by its gradual onset, absence of pain, tenderness, and other signs of acute inflammation, its slow and chronic course, and usually by the presence of tuberculous lesions of the prostate or in distant parts of the body. There is nearly always an associated periorchitis, with moderate effusion into the tunica vaginalis. (See Tuberculosis of the Testis and Epididymis.)

Orchitis.—Orchitis the result of direct trauma is described under Injuries of the Testis and Epididymis.

Orchitis of Urethral Origin.—The testis itself is very rarely affected in the course of acute gonorrhea, the infection being localized, as a rule, in the epididymis. In chronic inflammations of the posterior urethra, the prostate, the bladder, and as the result of instrumentation in these conditions, the testis may become inflamed alone or together with the epididymis. In these cases, though the gonococcus may be present in the urethra, the lesion of the testis is usually caused by other pyogenic bacteria. The inflammation may be subacute, ending in resolution. In other cases it is acute; and, though no abscess forms recognizable by ordinary methods of examination, a greater or less portion of the glandular substance is replaced by scar tissue. In some cases the process ends in suppuration or in necrosis of the testis. If an abscess forms in the testis, it may perforate the scrotum and be incised or burst spontaneously. A persistent sinus often remains.

Metastatic and Hematogenous Inflammations of the Testis.—Pyemia, septicemia, the acute exanthemata—notably variola, typhoid fever, pneumonia—and some other general diseases may be followed by orchitis, often of a suppurating type. Mumps, influenza, and polyarticular rheumatism may be accompanied by orchitis, very rarely followed by suppuration, quite commonly followed by atrophy of the testis.

Mumps is attended by orchitis in a fairly large proportion of cases. It is a common complication at or about the age of puberty and during early manhood. It is rare among children. The lesion of the testis may accompany, follow, or precede the inflammation of the parotid gland. One or both testes may be involved. Suppuration is very rare. Total atrophy of the testis is very common. In some epidemics atrophy has occurred in nearly one half of the cases. Orchitis during typhoid fever may be due to pyogenic microbes or to the Bacillus typhosus itself. Suppuration is common. Orchitis as a complication of the exanthemata is probably due to pyogenic microbes. Localization of a septic focus in the testis is occasionally observed in the course of septicemia and pyemia.

Symptoms of Orchitis.—The onset is usually sudden. If the process is of a suppurative character the general symptoms of sepsis will be more or less marked—i. e., fever, prostration, leucocytosis, etc. The testis becomes exquisitely tender and painful. It may swell in the course of two or three days to the size of a goose egg. The tension within the tense tunica albuginea causes

excruciating pain, not relieved by the recumbent position nor by elevation of the testis.

Physical Signs.—The scrotum is swollen, the skin smooth, the subcutaneous veins dilated; but unless the infection has already penetrated the tunica albuginea, the skin is neither red nor edematous. Upon palpation the testis is found enlarged. The surface is smooth, the normal shape of the organ is preserved. It is exquisitely tender, and feels firmer than normal. It is sometimes possible to palpate the epididymis as a ridge upon the back of the testis. If the tunica vaginalis contains much fluid, the recognition of the testis may be more difficult until the fluid is removed. When suppuration occurs the testis will become adherent to the scrotum, and the latter will be red and edematous. Fluctuation may be recognized. In certain cases total necrosis of the testis occurs quite suddenly without the formation of an abscess. In these the severe pain may suddenly cease after several days, often an indication that the testis is necrotic. In those cases which are permitted to rupture externally or incised for the evacuation of pus, a persistent sinus leading to an abscess cavity in the testis may remain behind. Some of these cases can only be cured by castration. The granulations sprouting from the interior of such a testis and the extruded glandular substance are sometimes spoken of as *benign fungus of the testis.*

A *chronic orchitis* may follow an acute attack, or in rare instances begin as such. Two forms have been described: one a diffuse type of interstitial inflammation, with marked increase in the size of the testis, the other characterized by the formation of minute circumscribed abscesses in the substance of the organ surrounded by masses of cicatricial tissue. Both these conditions are extremely rare.

Tuberculosis of the Testis and Epididymis.—Tuberculosis of the testis and epididymis occurs in two forms: (1) As a part of the lesion of acute general miliary tuberculosis; (2) as a localized lesion. The first form is of no interest from a surgical point of view. In the second form the epididymis is nearly always first affected, the lesion of the testis being due to direct extension. Much controversy has arisen in the past as to the mode of infection in cases of tuberculosis of the epididymis. The following facts have been determined by observation: Tuberculosis of the epididymis is rarely, if ever, a primary focus of tuberculosis in the body. It is often seen together with tuberculosis of the lungs, the joints, and the bronchial lymph nodes, and still more often is it associated with tuberculosis of other portions of the genito-urinary tract, the kidney, the prostate, the seminal vesicles, the bladder. The question in dispute has been whether the tuberculous lesion is primary in the epididymis and thence invades the prostate, or whether the infection proceeds in the other direction—namely, from the prostate to the epididymis. My own opinion is, that both methods of infection occur, but that the epididymis is first infected by a tuberculous embolus in the larger proportion of cases. I believe in an ascending infection from the bladder to the kidney, and also I believe that

tuberculosis of the kidney may produce secondary tuberculosis of any part of the lower genito-urinary tract.

While, as stated, the epididymis is usually first infected, the testis later, still, cases are observed in which the testis is undoubtedly infected first.

The Lesion.—The lesions of tuberculosis of the testis and epididymis consist in the formation of tuberculous nodules in the substance of the epididymis which undergo the regular changes—caseation, softening, the formation of cavities filled with creamy and cheesy material and lined by a wall of tuberculous granulation tissue. The overlying structures are finally invaded, the skin perforated, discharge of tuberculous material follows, and a tuberculous sinus remains behind, its external orifice being surrounded by a collar of typical tuberculous granulation tissue. The invasion of the testis follows the tubules into the substance of the testis and submiliary and larger tubercles develop in the substance of the organ. These coalesce, soften, and form tuberculous cavities of greater or less size, usually ending in total destruction of the organ. One of the commonest associated lesions of beginning tuberculosis of the epididymis is a periorchitis with a sero-fibrinous exudate in the tunica vaginalis, usually moderate in quantity. In a large proportion of cases tuberculosis of the epididymis and testis is associated with tuberculosis of the prostate. In a certain proportion of cases tuberculous infection of the epididymis follows injury, and gonorrheal epididymitis has sometimes preceded the manifestations of tuberculosis. The disease is most often seen after puberty and during early manhood, and yet it may occur at any age. The invasion of the epididymis is evidenced by the formation of one or more hard, painless, insensitive nodules in the head or tail of the epididymis, or both. The nodules increase in size rather rapidly, so that at the end of two or three months the head or tail of the epididymis may be as large as the last joint of one's thumb. Sooner or later softening occurs, with perforation of the skin, the discharge of tuberculous material, and the formation of a sinus surrounded by fungating granulations. The disease is extremely chronic.

Fig. 241.—Double Tuberculous Epididymitis with a Small Amount of Fluid in the Tunica Vaginalis of Either Side. (New York Hospital, service of Dr. Frank Hartley.)

I have seen patients in this condition going about without operative treatment for many years. Such patients may remain in fairly good health. In other cases they will suffer from loss of flesh and strength, and become anemic. In many cases there will be in addition the signs and symptoms of tuberculosis of the lungs, the bones, the joints, but more especially of other portions of the genito-urinary apparatus—the kidney, the prostate, etc. I do not know that I have ever seen a case of tubercular epididymitis whose urine was entirely free from catarrhal ingredients. When the testis is invaded it becomes swollen and lumpy, losing its smooth and evenly elastic contour; later on, after extensive softening has occurred, the tunica propria may be converted into a sac containing nothing but broken-down tuberculous material. Earlier in the disease the entire substance may be studded with tubercles the size of a No. 8 shot, or there may be larger circumscribed areas of tuberculous infiltration or softening while the remainder of the testis appears to be nearly normal. In this latter group of cases it has seemed to me probable that the testis was originally infected before the epididymis, since the lesion of the latter was less far advanced. The opposite finding is, however, the rule. In some cases the testis is notably increased in size; in others it is scarcely swollen. In a large proportion of cases the invasion of one testis is followed after months or years by infection of the other. This has been used by many surgeons as an argument in favor of conservative operations upon the tuberculous epididymis. It appears to me to be rather an argument in favor of castration in cases of tubercular epididymitis, especially when the remainder of the genito-urinary tract appears to be fairly healthy, since by this means we give the patient the best chance to preserve his remaining testis intact. Advanced cases of tuberculosis of the testis and epididymis are commonly associated with tuberculosis of the vas deferens. The vas is thickened, often nodular. As much of it as possible should be removed with the testis. In a small proportion of cases I have seen a tuberculous epididymitis run a very acute course resembling that of gonorrheal epididymitis. In some of these the acute inflammation subsided and became chronic; in one it was followed by acute general miliary tuberculosis and death in five weeks from the beginning of the swelling in the epididymis. In another it was followed by a rapidly fatal, generalized, tuberculous peritonitis. In a few cases, after the formation of sinuses, the disease may go on under favorable surroundings to what might be called an apparent cure. The sinuses close, leaving hard, cicatricial nodules in the epididymis, which may remain quiescent for years. Such cases are exceptional. In a few cases pyogenic infection occurs, with suppuration and destruction of the testicle. In many cases death occurs from tuberculosis of the lungs or from tuberculosis of other portions of the genito-urinary tract.

Prognosis.—The prognosis depends chiefly upon whether it is possible to remove all the foci of tuberculosis and to put the patient under the most favorable hygienic conditions.

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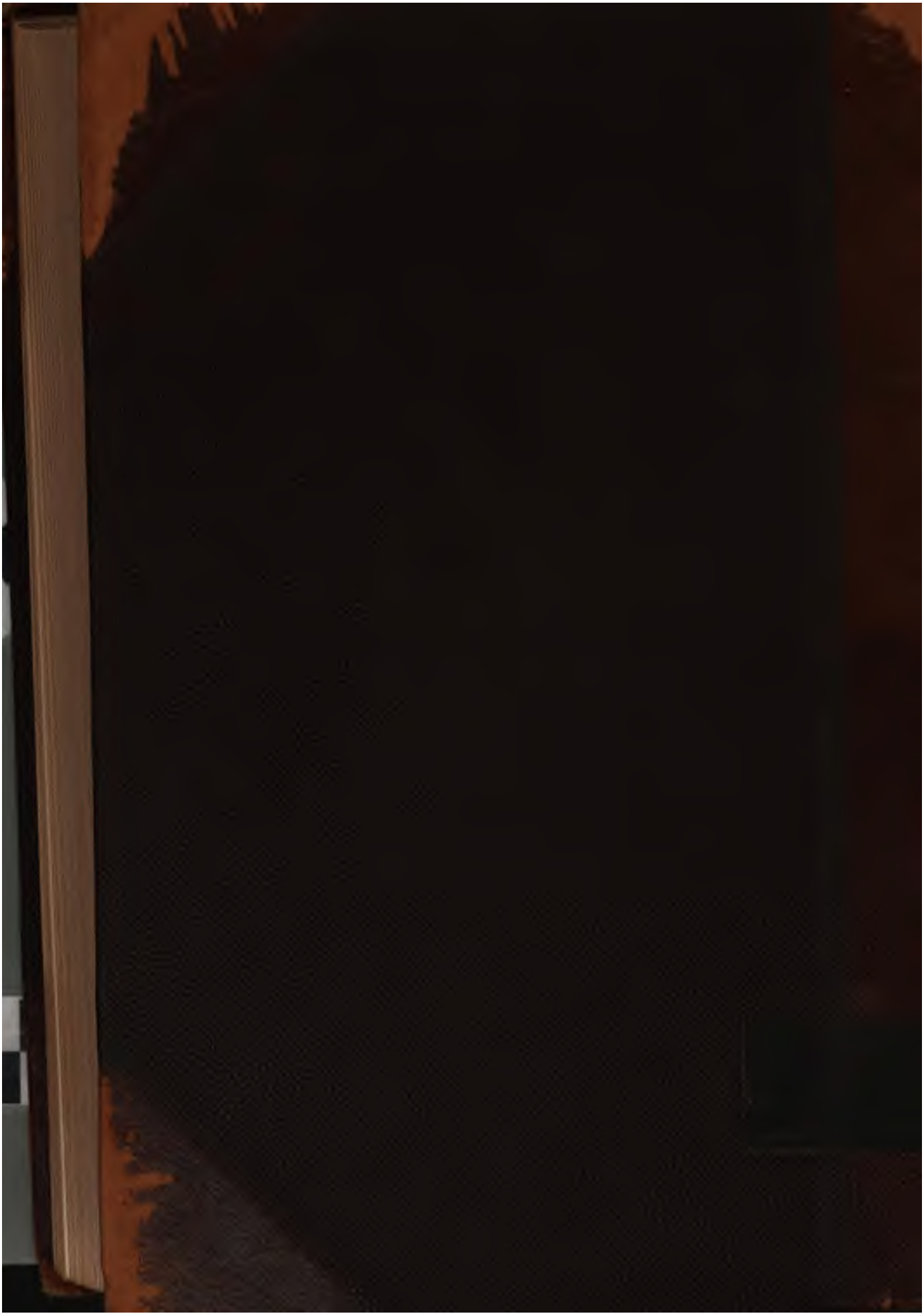
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